Strategies in Science Education

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students to science. Science, which is our attempt to gain better understanding of ourselves and the universe, is one of undertakings that makes man human. Probably, almost ev human being is born with some drive to inquire, discover and f out. Science is the cumulative, cooperative effort of mankind find out. Through the study of science, every student can t part in science. A few will prepare themselves for a life science.

In our science teaching, we have four major goals .

To help students consider the world view that has b developed in science as they develop their own view of world.

To master some of the processes of inquiry that are in science and that are among the most powe intellectual tools available to man.

To become literate in science so that the student can c inue to read and learn in science.

To nurture our innate curiosity and to develop a gre desire to continue to find out more about ourselves the world in which we live.

An examination of these goals indicates that some of t probably can only be achieved through efforts of able, dedi teachers of science. Generic approaches to problems, nurturing of the desire to inquire and discover, and a gen view of ourselves and the universe are best developed as a tea

ovides a model for his students. Actually, students study teachers well as books. In science some of the most important learnings can best be achieved through the study of the teacher and the model he presents.

If the teacher is of such central importance in science education, then teacher education is of critical importance. Not only must the science teacher know science in the sense that he is literate in science and know the operational meaning of important science concepts, the teacher must also serve as a model for his students. This means that he must teach in a way that is consistent with the nature of science. If science is a form of inquiry, then science teaching must be consistent with this mode of inquiry and a central function of teacher education should be to help future teachers serve as such models. Methods of teaching then take on a more profound significance. It is largely through the variety of methods of teaching that the able science teacher uses that he conveys some of the most important learnings in science.

The papers included in this book were used in the institutes on Science Methods at the Regional College of Education at Ajmer in the summer of 1969 as well as at Regional College of Education, Bhubaneshwar in the Summer of 1968. Hopefully, the materials will be of value in teacher education in science. Future teachers may wish to ponder many of the ideas discussed in this volume. The book should also be an important resource to teachers as they work with young students. It can be used as a resource to which they can occasionally turn for fresh ideas and intellectual support.

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many countries Goals for science Education at various levels are being worked out all the world over. A glaring defect in these efforts, especially in our country, is the insignificant involvement of the method masters at the teacher training college who in their turn are influencing a new generation of science teachers who again in their turn will be handling new curricular materials which are being developed at the national level In the history of Science Education, first effort in this direction was made in 1968 to organize a method master's Institute at the All India level at the Regional College of Education, Bhubneshwar. It was entirely a new experience both to the academic staff and the participants (mature and having long experience of teacher training colleges) Sixteen different types of activities comprising lectures, demonstration lessons, individual lessons, consideration of methods syllabi, history of science teaching, evaluation in science, field trips etc. were attempted. In 1969 the programme of the previous Institute was improved and Institute was conducted at the Regional College of Education, Ajmer. The experience at Bhubneshwar was of immense value to the director, Dr. A. N. Bose, despite the change in the academic staff at Ajmer. In 1969 majority participants were from teachers training colleges (which

cluded some good participants of the previous Institute at ubneshwar) and some experienced science teachers of hool. The academic discussions between the training college achers and the school teachers together with the resource ersons and the consultant, Dr. Jacobson was very effective. ortunately academic members of the Institute possessed not nly varied experience in teaching but also had personal xperience of the educational systems of U.S S R, U S A. & England. The college has been the originator of two mportant programmes namely; 'The Mobile Science show' ind 'Activities of Science Club Sponsors'. All these experiences resulted in having a successful institute

Objectives of the Institute

(i) to familiarize the participants with recent trends in science teaching and their implications

(ii) to examine critically the philosophy and psychology of instruction of science, that is, integration of matter and method in day to day classroom teaching.

(iii) to attempt to develop a commonly agreed science method syllabus for use in the training of science teachers; and

(iv) to focus attention on the channel of communications between school and training colleges, and thereby to promote a better understanding and appreciation of each other's teaching problems.

Why this book?

This is an important question to answer. There are several reasons for it.

(1) There is not a single book produced in India which deals with the different aspects of science education. This book will stimulate thinking in this neglected area.

(2) Current literature on methods of teaching science is inadequate. This book may satisfy the needs of the B. Ed. science students as well as the needs of the person, interested in science education.

(3) It is not the work of a single author to write such a book. The present publication discusses both extensively and intensively some current topics in Science Education. It attempts to give academic and practical wisdom in the solution of some problems.

(4) At one place, it attempts to add considerably to the body of literature at present available on science Education within the limits of our knowledge

(5) Taking an overall view, it continuously reminds us in the context of a frame work not only about the need but also the kind of path we have to take in upgrading science education in the country as judged by the international standards.

This book is divided into three part. Part first presents some basic considerations needed in the teaching of science, namely, relationship of science teaching to economic growth; outcomes of science education; role of methods; psychological considerations; evaluation in science and research in science education. In part two, trends in Science education (with particular reference to U.S.A., U.S.S.R., U.K., India), are given.

In part three science in the classroom is discussed. Intentionally appendices arei ncluded which give idea about soviet education on which literature is not available very easily.

It is our hope that the material presented in this book will be received warmly by the workers in the field.

Deficiencies if any, along with the suggestions for improvement will be highly appreciated by us. We are definitely aware of our limitations in a venture of this type.

Some of the material presented in this book has been taken from the Institute held at Bhubneshwar in 1968.

We shall be failing in our duties if we do not acknowledgde the immense help we received in conducting the Institute from Dr. Marjorie H. Gardner, Chairman of the Science Teaching Centre at the University of Maryland who worked as consultant at Bhubneshwar. Dr. Willard J. Jacobson, Chairman of the Department of Science Education, Teachers College, Columbia University who worked as consultant at Ajmer Mr. M. K. Gupta and Mr. S. B. Singh all from Regional College of Education, who worked as resource persons at Ajmer, Dr. K. S. Rao, Regional College of Education, who worked as resource person at Bhubneshwar.

Thanks are also due to Dr. R. C. Dass, Principal, Regional College of Education, Bhubeneshwar and Mr. P.D. Sharma, Principal, Regional College of Education, Ajmer respectively.

We are specially grateful to Mr. M. K. Gupta, and Mr. S. B. Singh for giving a shape to the work done in the Institutes in the form of this publication. In a book of this nature the work of many persons is merged. Naturally, editors are indebted to the contributing authors.

Lastly our thanks are due to all the participants of the Institute with whom we had interesting discussion, who took keen interest in the institute programme.

A. N. Bose

March, 1970 J. K. Sood

N. Vaidya

CONTENTS

Education and the spirit of Science

In the modern world the approach of rational inquiry the mode of thought which underlies science and technology is spreading rapidly and, in the process; is changing the world in profound ways........The spirit of rational inquiry, driven by a belief in its efficacy and by restless curiocity, is ...commonly called the spirit of science.

The term science is accurate but inadequate. It does not do justice to the fact that this mode of thought related also to questions men usually ask and answer for reasons which they think are totally non-scientific, religious, aesthetic, humanistic, literary. The spirit of science infuses many forms of scholarship besides science itself.

This statement attempts to define the spirit of science and to relate it to education. We believe that a greater awareness of that spirit would lead educators to assign to it a larger and more explicit place among the many goals of education.

The world-wide pursuit and spread of science and technology are commonly recognised. There is less recognition that the values and modes of thought which underlies science and technology also are becoming pervasive in the world. Yet these values and associated modes of thought may in the long run be more important to mankind and to education than the visible fruits of scientific and technological pursuits.......science and technology on the one hand arouse the expectation of a better way of life to give promise of material satisfactions, and hold forth greater responsibi-

lities for the development of human potentialities They give rise to a genuine optimism and excitement. But they also give rise to anxiety.........to a gnawing apprehension of man's alleged loss of personal freedom, of certitude, of psychological security, of identity.

....aware of the apprehensions aroused by the penetration of the scientific spirit, we conclude that the hopes it offers so greatly outweighs the drawbacks as to justify a major recommendation : that a general worldwide fostering of the spirit of science is wise. This conclusion has implications for American foreign policy.

Recommendations

The schools should try to realize the great opportunities which the development of science has made apparent in the world. They can do this by promoting understanding of the values on which science is everywhere based. Although no particular scientist may fully exemplify all these values that characterize the enterprise of science as a whole.

1. Longing to know and to understand.
2. Questioning of all things.
3. Search for data and their meaning.
4. Demand for verification.
5. Respect for logic.
6. Consideration of premises.
7. Consideration of consequences.

......These values.........are part and parcel of any true education . These are characteristic not only of what

is commonly called science......, but more basically, of rational thought......and that applies not only in science, but in every area of life. What is being advocated here is not the production of more physicists, biologists or mathematicians, but rather the development of persons whose approach to life as a whole is that of a person who thinks... ......a rational person. The characteristics of this mode of thought merit consideration in greater detail.

........To communicate the spirit of science and to develop people's capacity to use its values should therefore be among the principal goals of education in our own and every other country.

'Education and the Spirit of Science' Educational Policies Commission, N.E.A., U.S.A., 1966.

SCIENCE EDUCATION:

BASIC CONSIDERATIONS

The treatment of science as enquiry is not achieved by talk about science or scientific method apart from the content of science. On the contrary, treatment of science as enquiry consists of a treatment of scientific knowledge in terms of its origins in the united activities of the human mind and hand which produce it; it is a means for clarifying and illuminating scientific knoweldge.

Josheph J. Schwab
The Teaching of Science
Cambridge, Mass : Harvard
University Press, 1962.

Science Education and Economic Growth

Willard J. Jacobson

The young child looks at the world around him and he sees rocks and soil, plants and animals, oceans and sky, moon and stars. He wonders about them. As he looks a little closer he also sees the houses in which we live, the clothes that we wear, the food that we eat, the automobiles on the road, the airplanes that hum overhead, and the radio that breaks the silence. He wonders about these too. He may also see people, and these people are sick or well, hungry or satisfied, ignorant or well-informed. We hope he wonders about these as well.

In many respects our concerns in science are much like those of the young child. We wonder about the environment in which we live, and we try to gain a better understanding of it. We study the tools, machines, and artifacts of civilization to try to gain a better understanding of them and to use them for the benefit of a greater number of people. Also, we are, and should be, concerned with the problems that face people throughout the world: making the most of meager resources, relieving the pain and suffering of ill-health, studying human populations and the possibility of controlling their numbers, and investigating the problems that people face as they try to learn science and use it to improve their lot. The curiosities of the child and the problems of mankind are proper concerns of those of us who are engaged in science and science teaching.

"Education is an integral, indispensable part of the

entific enterprise." For example, although we have rned how the nutritional deficiency disease *kwashiorkor* n be prevented, the problem is not solved as long as large mbers of people are not aware of this knowledge or of w to use it. This is largely an educational task. Similarly, scientists and engineers are dependent upon education. he scientist or engineer who does not educate himself and hers is threatened with obsolescence. Without continuing lucation he may find himself out of the mainstream of his eld and floating in a stagnant pool going nowhere. Of ourse the education of new scientists and engineers is of ritical importance for the development of the scientific nterprise and for the economic growth of a nation and region. The educational dimension of the scientific enterprise is the only avenue through which there can be a constant infusion of new, young blood and fresh, invigorating ideas. In any programme to develop the scientific enterprise in a nation or region the critical importance of education must be recognized.

Science Teaching for Economic Growth

The ingredients of economic growth are fairly well-known. Among the ingredients are : natural resources, skills and know-how, energy and ingenuity of people, the capital necessary to develop the technology to make the optimum use of skills and energy, and some reasonable relationship between natural resources and the human population that must exist on those natural resources. Apparently, all of these ingredients must be present. The lack of one ingredient may be a serious limiting factor to economic growth. There are, for example, nations that are comparatively rich in natural resources and yet have achieved very little economic growth. There are other nations who seem to have all the ingredients, but the overwhelming pressure of a large and growing population holds down the standard of living.

In many cases inadequate educational programmes inhibi growth.

One of the important steps in planning programmes o education is to analyze the economy of a nation or region t determine the factors that are limiting the rate of economi growth. Are the limiting factors unwise use of natura resources, antiquated technology, or serious public healt problems? Usually, expert help is needed in this analysis, an there should be no hesitency to use the knowledge and ins ghts of economists, agriculturists, engineers, public healt specialists and other experts. Since an improtant dimensio of many of the ingredients for economic growth is educatio the education programme should be planned so that it wi contribute to the removal or diminution of factors limitin economic growth.

Effective programmes of science education are essential f optimum economic growth. The remainder of this paper devoted to a discussion, with examples, of some of the contr butions that can be made to economic growth through scien teaching. The examples used to illustrate these potenti contributions are drawn from experience in several regio of the world.

Wise use of natural resources Among the natur resources that can be used for economic growth are so fresh water, rocks and minerals, fuels, water power, sol energy, animal and plant life, the oceans, scenic landscap and the energy and ingenuity of the human populatio Considerable insight and know-how is needed to make t optimum use of these resources.

In the vast region stretching from the Atlantic Oc through North Africa, the Middle East, large parts of So

monsoon regions of the subcontinent of India, one of the major limiting factors to economic growth is the lack of water. It is essential that the nature of various sources of water be understood and that the wisest possible use be made of the available water.

The students in one school in South Asia made a study of the available ground water supplies and learned some of the precautions that should be taken in using ground water. The school was located in a mountain valley. Considerable amounts of snow fell on the mountain peaks during the winter and, as the snow melted, some of the water filtered into the ground to become part of the ground water supply.

The students made a study of the fluctuations of the level of the ground water table throughout the year. The level of the water table may be defined as the level to which water will rise in a dug well. There were several such wells near the school and the students devised ways of easily measuring the height of the water in these wells. From their measurements they developed graphs. From these graphs they could get some indication of the changes that take place in the ground water supply in that valley throughout the year. On the practical side they could use the graphs to determine the best time for digging new wells. In fact, one of the projects they undertook was the digging of a new well to provide water for the irrigation of their school garden. They were puzzled by the considerable difference in the height of the water table in two of the wells that they studied. As in more sophisticated scientific research, among the most important products are unanswered questions that require further research.

These students also learned how to use ground water safely. They studied the effects of filtering water through soil and learned that this is one of

the ways that water can be made safe for human use. They learned how water-tight covers and casings could be made for wells so that they could be certain that all of the water that was drawn from the well had actually been filtered through a considerable amount of soil. These were important understandings because in this region wells could be among the safest sources of drinking water.

The ways to make the wisest use of soil resources va greatly from region to region. In regions where th is considerable rainfall, there is a tendency for basic s materials, which tend to be quite soluble in water, to leached out of the upper soil horizons leaving the soil co paratively acid. For the optimum use of these soils, lime other basic materials often must be added to reduce soil acidity. In these regions it is also important to red the amount of topsoil that is washed off by the runn water. In acid regions, however, the soluble alkaline ma rials tend to be brought to the surface of the soil by capillary rise of ground water. At the surface the wa evaporates leaving such alkaline materials as gypsum salt at the surface. If the acid land is to be irrigated, alkaline material has to be leached out of the soil drained.

A great river valley was being developed. Fresh water from the melting snows in the mountains was being stored in a great reservoir at the headwaters of the river. The dam prevented floods in spring and provided water for parched lands during the dry months of summer. With water there were hopes that the desert would bloom with grass and grain, cotton and sugar beets.

The desert land was alkaline, and the alkaline soil materials would have to be removed. To do this, deep drainage ditches were dug, and larg

quantities of water were poured onto the land and allowed to seep down through the soil. The alkaline materials dissolved in the water, and the salty water seeped into the drainage ditches to be carried off into the river. When enough of the alkaline material had been leached away, crops could be grown.

However, water had alway been a precious commodity in that region, and to some of the farmers it seemed a pity to have precious water carried away from their land. They dammed the irrigation ditches and put the salty water back on the land

The children in one of the schools in the region made a study of this leaching and drainage process. They studied a map of the valley showing the locations of the irrigation canals and drainage ditches and heard explanations of how the valley soils were to be made suitable for agriculture. They collected samples of water from the irrigation canal and from one of the drainage ditches, evaporating the water, and compared the amount of salts remaining from each sample. They filled several flower pots with leached and unleached soil. They planted various kinds of crop plants in the flower pots and studied their growth. They also found farmers who were trying to grow crops on both leached and unleached soil and were able to compare the plants grown on each of the plots. Through these kinds of activities, the children gained a better understanding of the processes that were being used to make better use of the soil resources in their valley.

In some regions of the world economic growth is imited by a lack of fuel and other sources of energy. Fortunately, many of these regions are ideally located for the tilization of solar energy. They are in the low latitudes where the solar energy received per unit area is comparatively

large and there are few clouds to reduce the amount of su
light that reaches the surface. Solar energy is of limi
value industrially because to get substantial amounts of ene
it has to be collected from a very large area. Howev
solar energy can be used to heat water, cook foods, h
homes, and, in general, raise the quality of living in a hor

Children and young people have made and studied various devices for the collection and utilization of solar energy. One group of students constructed a small solar hot water heater utilizing the greenhouse effect, the ability of dark objects to absorb solar radiation, and the convection effect when a fluid such as water is heated. Groups of children have built solar energy reflectors out of metal foil and used the reflectors to warm food. Of course, many a youngster has used convex lenses to concentrate solar energy upon a point and, in some cases, to start fires.

The study of solar energy and how it can be utilized brings the student into contact with some of our most important scientific principles. Among the scientific principles that the student may use are:

The greenhouse effect
Absorption of energy by dark coloured objects
Refraction of light by lenses
Reflection of light by mirrors
Selective transmission of solar energy through the earth's atmosphere
Energy transmission by radiation, conduction and convection
Photosynthesis
Latitude and amount of solar energy received

There are many who suggest that such principles can be taught through the consideration of a topic such as solar energy that the students recognize as being of value to them (2).

Healthy Living Not only is good health essential for the well-being of the individual, but it is also necessary for the social and economic growth of a nation or region. Anyone who has suffered from the alternating chills and fever of malaria and has felt his energy stripped away by this widespread disease can appreciate how the vitality of entire nations and regions can be sapped by disease. Pellagra, kwashiorkor, dysentery, yaws, typhoid fever, bilharzia, and tuberculosis are among the many diseases that sap the strength and energy of individuals and leave little left for growth and development. Any diminution of these poxes and pestilence will release energy and drive needed for economic growth.

Education, and particularly science education, is essential for the control and reduction of disease. Many diseases are carried by various vectors such as the mosquitoes and flies. It is essential for the individual to know how these diseases are spread, some details of the life cycles of the insect vectors, and the points in the life cycles where the insects are amenable to control. Similarly, functional diseases are often due to ignorance. Malnutrition, for example, is often found in places where the necessary nutrients are available, but ignorance may keep them away from those who are in need.

Those who plan science programmes should inform themselves of the health situation in their regions. What communicable diseases are common? What are the major causes of death? What health measures should be undertaken by the individual and the public? What environmental factors lead to poor health? How can they be corrected? With answers to questions such as these, the science educator can plan science programmes that "make a difference."

In regions of Central America and Panama there are very serious health problems, particularly

among the children. Until recently, among the Indian and Ladino populations "Every year about 170 in every 1,000 in the age group from one to five years die." Many of these deaths are directly or indirectly due to the protein-deficiency disease *kwashiorkor*. There is no accounting of the loss in energy and vitality due to this disease.

In this region, kawshiorkor is due to a lack of two amino acids, trytophan and lysine, in the diet commonly eaten by young children after weaning. Ordinarily, these amino acids are obtained largely from animal proteins. These animal proteins are often available in the home and are eaten by older members of the family, but for a variety of reasons, including ignorance, they are often not given to young children.

Kwashiorkor has been subjected to intensive research for a number of years. Its causes, effects, treatment and methods of prevention are known, and a relatively inexpensive food *(Incaparina)* using indigenous food materials has been developed which will supply the needed amino acids. Now, however, the results of these efforts must be made available to the people throughout the region.

As is the case in most effective public education programmes, a wide variety of approaches needs to be used. Child care clinics and agricultural extension services have been initiated; radio and television programmes have been planned; films have been made; resource materials for teachers have been prepared; and an excellent set of children's books related to nutrition has been written. An imaginative programmes of in-service education for teachers and educational leaders has been planned. It has been reported that the annual child death rate has been reduced from 170 to about 70. This is heartening progress, but obviously much more needs to be done (3).

Earth has been increasing at a rapid rate for the last 300-400 years. It is estimated that the earth's population in 1962 was 3.1 billion and that it was increasing at a rate of 2.1% per year. To add to the complexity of the problem, a large fraction of the earth's population is located in regions that have relatively few natural resources and therefore have camparatively limited potentials for economic growth.

If we are to have satisfactory standards of living, it is becoming apparent that we must find some way to control population growth. As with other problems of this nature, a variety of approaches must be used. Certainly, one approach that can be used in science education is to help young people to gain a better understanding of the processes of reproduction and the scientific bases for various methods of reproduction control.

At Teachers College, Columbia University some prototype materials related to the population problem are being developed for use in secondary schools and particularly in secondary schools that prepare primary school teachers. These materials are not intended to give explicit instructions in method of control of reproduction. Instead, they are designed to provide background information that will help the student to gain a better understanding of the processes of reprodution and the points at which they can be controlled.

Reproduction is analyzed in terms of *critical stages*. The critical stages are those points in the reproductive process where accidents or purposive intervention may prevent reproduction. For example, a critical stage in the reproduction of flowering plants is in the transfer of pollen from a stamen to a pistil (often of another plant). If this transfer does not take place the sexual reproduction of this

plant does not take place. Our methods of controlling reproduction usually involve intervention at one of the critical stages.

In the prototype materials, the sexual reproduction of three organisms is analyzed: flowering plants, the frog, and man. In each case the critical stages are identified. This background information should help students to a better understanding of various approaches to birth control. It is hoped that these prototype materials can serve as a basis for the development of instructional materials in biology that can be tried out in schools.

Skills and understandings A middle-aged man with a wife and several children was ironing with an electric iron. Unfortunately, it had just rained, and he was standing in a pool of water. His hands made contact with the ends of the extension cord. The electric current passed through his body, and he was instantly electrocuted. An understanding of some of the basic principles of electricity would have prevented this death.

Ever since the mine has been opened, the powdered coal has been pulled out of the mine by either donkeys or the miners themselves. Now, a winch had been provided that was powered by a gasoline engine. But how do you start and operate a gasoline engine? The answer is simple, "Follow the directions printed on a metal plate fastened onto the engine." But, in order to follow the directions it is necessary to be able to read them. In this case, it was even more difficult because the directions were in a foreign language, and the use of the new winch had to await the arrival of someone who could read the directions and instruct some of the workers as to how to operate the gasoline engine. Literacy, sometimes literacy in a foreign language, is often essential for economic development.

The amount of soil that will be carried away by running water is dependent upon, among other factors, the velocity of water. One of the ways to prevent soil erosion is to slow the downhill flow of water. Among some of the peoples of northern Europe it was a mark of skill and a sign of good farming to be able to "plow a straight furrow." In some cases the straight furrows might go up and down a hillside. It is possible to plow in this way without great damage in regions where the rain only falls in a light drizzle. However, if these patterns of farming are transferred to regions where there are torrential rainstorms, ditches and huge gullies may be quickly formed and good farm land may soon be ruined. In many regions it is essential that our children and young people gain an operational understanding of the scientific principles on which soil coservation is based.

It is possible to double, triple, or even quadruple agricultural production through the use of hybrid seeds. However, the development of strains of various plants and animals that will thrive under various climatic and ecological conditions requires skills and understandings of a very sophisticated order. At one level, someone must understand some of the basic principles of genetics and know-how to select the strains, carry out the tests, and plan for the production of hybrid seeds. Others must have the technical skills needed to control the crossing of various strains. The farmer who uses hybrid seeds must have some understanding of their nature; at the very least he must understand that it is not wise to use the seeds from hybrid plants for future plantings.

: Economic growth requires that more and more people develop scientific skills and understandings. The skills and understandings that have been discussed are only illustrations

of the many that are needed. Anyone attempting to make a complete list would face a formidable task.

In most cases it is probably not desirable to try to develop, in school, the specific skills needed in an industry. Usually, this can be done more effectively on the job. However, it is essential that the students in our schools master the broad principles of science on which most developing economies are based. For example, it is probably not efficient to try to teach in school the skills that a technician needs to install and maintain telephone systems Instead, the future technician should be taught the basic principles of electricity on which all telephone systems are based. An understanding of these basic principles is essential in many other occupations and professions.

Continuing education Change is taking place at an unprecedented rate in science, technology, and education. Too often, the initial reaction of individuals to change is resistance. In some way we must help our students to make the most of change. New developments should be investigated and analyzed, and those that hold promise for improving our lot should be tried. In a sense we should educate our students to seek to continue their education throughout their lives.

> Strains of rice have been developed that give 2-3 times as large yields as those that have been traditionally planted. Although this would seem to be the kind of development that would be eagerly sought by rice farmers everywhere, it has reportedly been very difficult to achieve widespread acceptance of this new kind of rice. Apparently, one of the obstacles to be overcome is simply that of informing farmers that this new kind of rice is available. The task would be much easier if these farmers had had an education which stressed openmindedness and the search for new and better ways of doing things.

The incidence of many diseases can be reduced greatly by simple precautions. The debilitating effects of hookworm, as well as several other diseases can be largely prevented by providing simple facilities for disposing of human excreta. Sometimes, badly needed nutrients may be obtained from plants that can easily be grown in home gardens If we can educate a generation that will be open to ideas, amenable to change, and will seek better ways of doing things, we shall have helped develop conditions which will make it possible to speed up the rate of change.

It will be especially important that education partake of continuing education. New technology and new teaching materials will become available at an increasingly rapid rate, and it is essential that educators make the optimum use of them.

We have not made optimum use of radio. Radio is especially important as a way of reaching people who have not acquired minimum literacy skills. Television has similar potentials. Television may be of special importance in regions that have extreme shortages of competent teachers. Television may be a way of spreading the talents of a small teaching corps over a larger population.

Programmed instruction is of special value to *highly motivated individuals who wish to* prepare themselves in special fields. Students may use programmes to prepare themselves in areas where other kinds of instruction may not be available.

New science materials are being produced in many nations. In some cases, these materials constitute new approaches to science. These materials may or may not be applicable elsewhere, but certainly educators should be aware of them and consider them as they continue their efforts to improve their science programmes and science teaching.

Science education Research The test of science programmes and science teaching is an empirical one. "What do the students learn"? If there is to be continuing improvement of science education, it is important to undertake research. Through research we are better able to differentiate between what we *wish* would happen and what *does* happen.

Evaluation studies are of special importace. When new courses or new approaches to teaching are developed, an attempt is made to state the objectives in such a way that it is possible to check the extent to which these objectives are achieved. Tests and other instruments are developed to determine student growth in the direction of objectives. Student growth may be compared to growth of similar students who have not been involved with the new courses or the new ways of teaching to try to ascertain the relative effectiveness of the new approaches to science teaching.

Science learning studies Studies of students and how they learn can be very helpful. What kinds of experiences related to science have children had before they come to school ? What concepts do they have regarding various natural phenomena? What kinds of arrangements for the study of science seem to be most effective? There is a wide range of studies that will be helpful in improving science instruction. In addition such studies would be important contributions to comparative science education.

Historical studies Eventually, it will be important to carry out historical studies that will analyze the experiences of developing various kinds of science programmes. What have been the critical factors in the development of science programmes? How have various kinds of programmes contributed to the economic growth of nation and region? If such historical studies are to be undertaken, it is important to keep systematic records and save primary documents and other data.

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This paper is partly based upon the paper prepared for the Congress on "Science Teaching and Economic Growth" sponsored by the Inter-Union Commission on the Teaching of Science held at Dabar, Republic of Senegal, January 14-22, 1965.

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Outcomes of Science Education

N. Vaidya

Back ground

Science Education is under fire all the world over for different reasons. The developing countries, usually rich in resources but full of poor people, see in science and technology their only hope of quick economic recovery and widespread prosperity. This, of course, is a poor appreciation of science on their part. The developed countries, on the other hand, besides this, show too much concern about the nature, philosophy, and outcomes of Science including technology. 'Education and Spirit of Science', a tiny volume published by the Educational Policies Commission in U. S. A. brings forth this point quite forcefully in the following words:

> The world wide pursuit and spread of science and technology are commonly recognized. There is less recognition that the values and modes of thought which underlie science and technology also are becoming pervasive in the world. Yet these values and associated modes of thought may in the long run be more important to mankind and to education than the visible fruits of scientific and technological pursuits. Science and technology on the one hand arouse the expectation of a better way of life, give promise of material satisfactions, and hold forth greater responsibilities for the development of human potentialities. They give rise to genuine optimism and excitement. But they also give rise to anxiety-to a gnawing apprehension of man's alleged loss of personal freedom, of certitude, of pyschological security, of identity (1).

The report stresses that the schools should make special effort to familiarize their students with the nature of scientific enterprise characterized by values like 'longing to know and to understand, questioning of all things, search for data and their meaning, demand for verification, respect for logic, consideration of premises and consideration of consequences' (1).

Philosophy of Science (Scientific Method)

One gets into difficulties when one looks for a single definition of Science acceptable to all. It is really shocking to know that science tends to defy its own definition. For Bently Glass, it is the 'unfinished business' which stretches much beyond the definition in concrete terms as given by Prof. Percy Bridgman in which he says that science processes involve 'accurate and precise description, classification, repetition, consensus, experimentation and measurement'(3). For W.Pauli, 'it is not the fixed questions to the fixed answers (both can vary depending upon the questions to be pursued) but to attain the understanding of the relationship which connects the answer to the problem' (4). C. P. Snow goes a step further saying that 'scientific culture is not only intellectual but also anthropoligical'. Even the scientists do not appear to understand each other completely. What applies to science also applies to scientific method which turns out to be a significant ingredient of the philosophy of science, and the functions of the latter are to define and redefine science concepts, identify the various areas of scientific research which can be more profitably and productively attacked, investigate assumptions underlying the nature of reality and to present a coherent and consistent picture of reality based upon findings in the different branches of Science (5).

Views also differ widely on what actually constitutes

a 'scientific method'. Some say that there is a sc method and various steps in it can be identified an made the specific objectives of teaching. There are who say that there is no such thing as the scientific r Everyone has to find his own path and in this wide scientific investigation is pathless with no restrictions soever imposed on it. There is then no sanctity as the rigidity regarding the steps of the scientific which have acquired a 'natural status' like the s problem solving with the passage of time. This that the use and practice of scientific method does not guarantee a solution to the problem. Consider the ing examples:

Take a recent example. We still do not kn exactly the insertion of the loop checks pregnancy. answers so far obtained to this problem are at the hy stage but the medical research is not idle on this material and shape of the loops is continuously being ved upon which may throw light (may be dim) l Scientists obtained conflicting results on the eff vitamin C which were reconciled later on by the d that the rats possess the inherent ability to man vitamin C out of the diets fed to them. About 250 ago, Pythagoras, great mathematician, hypothesize on arguementation about the shape of the earth took his hypothesis seriously till Columbus made a like use of it. The planet Urnaus did not behave a cated mathematically. The result was the discover other two planets, namely, Neptune and Plato. E clean, neat and highly sophisticated method and pr of Louis Pasteur, whereas confirmed that the living always come from the living bodies but it did not an basic problem of the origin of life. The scientists thro ntific method accepted and rejected the conflicting evi

the nature of heat and light, the controversies which rocked the scientific world for years. Jan Van Helmont, one of the very well known and highly respected scientist of the 17th Century left an interesting method of making mice : take slightly soiled shirts, place them on a dim, quite corner sprinkle with kernels of wheat, and in twenty-one days one would have mice. It was as much a demonstrable recipe as any other demonstration today for it did work in those days. The Indian scientists failed to suggest a suitable dye to colour the Dalda Ghee. They suggested that the problem be discarded as the solution developed may turn out to be more irksome than the problem tackled. Try, if you can to separate sugar from milk sweetened by it. History of Science is full of such examples.

Steps in Scientific Method

The problem to a certain extent is solved if we introduce the new terms namely, stable inquiry and fluid inquiry (2). In fluid inquiry, the research scientist questions the existing body of knowledge in his developing theoretical frame of reference which is fundamentally at variance with the established body of knowlege (Kepler, Newton and Einstein). They are in fact the leaders of the scientific world whose first concerns are to explore the problematic areas sometimes even across several disciplines through self made rules which afterwards become an integral part of the scientific method and philosophy of science. They thus succeed to illuminate how to bend method and procedures to catch highly diverse and evasive ideas. In contrast to this in stable inquiry, the research scientist fills in a blank in the growing body of scientific knowledge. It is through stable inquiries that the new knowledge is studied intensively, refined, extended, standarldized and assimilated.

Some one then again rides on the hump of the camel

or may hurdle against major discovery (Radio activity, X rays, skeptical challenge of Einstein, splitting the nucleus through mechanical means and the basic work leading to the manufacture of atom and hydrogen bomb). It is fruitless to look for further fine distinctions between these two inquiries until the computers begin to think creatively. They infact coalesce into each other. This is the reason that sometimes it is difficult to distinguish between original sense and non-sence (can particles travel faster than light ?). Against this background, one can enunciate the following steps of the scientific method.

Steps in Scientific method

a. Encountering the problematic situations

b. Statement of the problem (its formulation more and more productively)

c. Forming hypotheses (Trial ideas or tentative stabs with no restrictions whatsoever imposed). One should enlist all the possible hypotheses like 'Brain Stroming' in industry for there is no distinction between relevant and irrelevant hypotheses at the stage.

d. Setting up control experiments. Much ingenuity is needed at this stage. The first best control experiment is one which discards atleast 50 p.c. of the hypotheses. It costs time and money if one sets up one control experiment to confirm or discard one hypothesis.

e. Obtaining relevant variables after all the hypotheses have been screened.

f. Discovering the mathematical relations (This makes the solution more powerful).

g. Application of the above to solve new problems

h. Idealization and abstraction. It is the last stage in the development of a solution which links it with the philosophy of science which is a part of general philosophy (9).

Outcomes of Science Education

We don't have a pin-pointed discussion on the outcomes of Science Education for various categories of children at various age level right throughout the school. The discussion is too general to mean anything. In a study we found out the following objectives of teaching general science:

(i) to enable them to live in a scientific world, environment and to draw inferences to solve the related daily *problems; to experiment* and *handle scientific* apparatus,

(ii) To make students familiar with,...

(iii) To create interest in science, pratical work, art, about things of daily use and for manual work.

(iv) To develop keen observation reasoning capacity scientific thinking, habit of criticism, judgement, critical understanding, imaginative powers and interest in science

(v) Development of scientific attitude, (cause and effect relationship and not to be led by superstitions) outlook, research attitude, examination and promotion of thinking.

(vi) To increase (or impart) scientific vocabulary and add to the *fund of knowledge*

(vii) To impart knowledge about the laws of nature.

(viii) To introduce them (*pupil's*) to some scientific apparatus

(ix) To appreciate the place of science or role of science in modern age.

(x) To acquaint students with scientific inventions, natural objects and their utility.

(xi) Development of traits like carefulness, self confidence, tolerance, encouragement, independence, feeling and will of cooperative action and self dependency.

There is nothing wrong with these statements. They infact look grand on paper. It is however obvious that these objectives cannot be achieved in one lesson. It is therefore important for us not only to state the objectives of instruction specifically but also to consider their other aspects more comprehensively. The latter are now mentioned below :

1. **Functional Understandings**
   (a) Scientific vocabulary
   (b) Scientific fact
   (c) Scientific concept
   (d) Problem solving leading to training in scientific method.

2. **Scientific skills**
   (a) General skills; language skills, i. e. reading and writing.
   (b) Communication skills, viz, speaking and listening including dramatization.
   (c) Social skills, viz, to get on with people, respect for others and their property, self competition, working effectively in groups, cooperation and emotional stability etc.
   (d) Library skills viz, findings various and varied references and consulting them.
   (e) Laboratory skills viz, experimental skills needed in

the laboratry to get up apparatuses, make observations, record observations, plan for experiments, *improvise apparatus and develop preservation skills.*

(f) Mathematical skills, viz, computation, graphing, ranking, averaging, approximating, geometrical *drawing, dealing with symbols and reading tables.*

(g) Aesthetic skills viz, artistic sensitivity and physical ability to prepare charts, models instructional and *illustrative materials.*

(h) Safety skills viz, avoiding accidents and the ability to do first aid whenever needed.

(i) The abstract skills viz, ability to recognize and classify things on the basis of common characteristics, ability to analyse simple and complex *problematic situations, ability to check evidence,* ability to verify one's ideas, ability to judge absurdities, irrelevancies and fallacies, ability to set up control experiments on the basis of hypotheses considered and thereby to distinguish between relevant and irrelevant variables and the development of *insight into the nature underlying assumptions* and proofs.

3. Scientific Attitude

a. Open mindedness
b. Curiosity
c. Judgement based upon scientific facts alone
d. *Willingness to test and verify conclusions*
e. *Faith in cause and effect relationship*
f. Honest reporting
g. Rejection of the principle of authority
h. More faith in the books written by specialist in their respective fields etc.

Scientific Interest

(a) Making collections (seeds, leaves, flowers and minerals etc.)
(b) Making simple preparations (oil, soap and chemical)
(c) Making improvised apparatus
(d) Making scientific models
(e) Setting up some demonstration expriments
(f) Visiting places of scientific interest
(g) Interest in some multifarious activities of the science culb
(h) Reading scientific journals and popular books
(i) Describing experiences of scientific interest
(j) Interest in science as a field of vocation.

Scientific appreciations or Inelltectual admirations (to wn from)

(a) History of science, scientific discoveries and inventions
'b) The state of science in different centuries.
'c) Biographies of scientists
d) Impact of modern science on daily life and its implications for the future of mankind.
:) Contribution of science to food, shelter, clothing health and hygiene, etc.
) Physical environment and environment created by man (8).

t us now discuss only the first aspect, namely the understandings.

ctional understandings It is not possible to define l understanding" in one phrase or in one sentence. ven possible to perceive it as it arises in the

child's mind i.e. whether it is only a word, a fact, a concept, a principle or something composite called functional understanding. The lines to follow do not, therefore, throw light on this aspect of the problem.

Scientific Vocabulary It refers to words like mixture, compound, valency, spectrum and electron etc. which are used frequently in the scientific literature and constitute an essential part of understanding clearly the scintific thought. The development and knowledge of scientific vocabulary at various grades is essential because only then the children can read and study a paragraph of science with satisfaction, confort and understanding

Scientific fact It is a statement of an actual event of a physical object. It is mostly empirical in nature. Some examples are :

1. Water boils at 100°C.
2. Heat changes water to steam.
3. Air is invisible to eye.
4. Sun rises in the east and sets in the west etc.

Scientific concept Concept is an idea about the environment which may be a variance with tested scientific knowledge. A scientific concept cannot therefore be used in this sense for it does not inform us how it was psychologically formed. Generally speaking, it not only underlies a group of scientific facts but also explains them. Its distinguishing characteristics are :

1. A scientific concept is not always an isolated fact or even a specific fact about a given phenomena or object.
2. A scientific concept is objective in character. It

simplifies. standardizes, and inter-relates the various experiences.

3. A scientific concept explains a certain aspect of the phenomena, certain mode of reaction, or behaviour, or a certain relationship or it governs agroup of facts.
4. A scientific concept is a scientific fact which does not contradict itself without violating some other equally established law.
5. It is a practicable and usable statement specifically worded to be true within its statement.

These considerations apply only for a certain length of time because the fundamental ideas of science also change with the passage of time. Secondly, the above mentioned outcomes of science education are, infact, broad categories which are not to be at all considered independent of each other On the other hand this further necessitates additional specific statements not only about the subject matter in a given area of science but also inclusion of corresponding learning experiences, that is, an integral part of each other.

Behavioral objectives

Our problems do not appear to end here. The reason is that we have not so far brought specifically into our thinking, habits, what actually do we wish to achieve. It is so essential in evaluation. Therefore a given behavioral objective tends to achieve the following purposes :

(a) To identify those students behaviours which correspond with a given set of content or process materials in a curriculum and to guide instructional planning to achieve these behaviours.

(b) To provide criteria for the selection of learning experiences.

(c) To provide a means of evaluating the outcomes of any instructional experience.

(d) To provide criteria for analyse and revision of learning experience in terms of the original or new discovered objectives (10).

It is easy to see that our thinking on objectives is becoming gradually more and more specific. One will not use undefinable terms or statements like (to understand, know, appreciate and familiarize etc.) but one will use measurable terms like the following in stating the objective of instruction : classify, construct, calculate, select, describe, order, write, transfer, demonstrate, distinguish, design, synthesize, apply; state, analyse and evaluate (10). It is our hope that thinking in this direction will improve science teaching in our country provided attempts are made in a big way in our country to involve practising teachers in discovering means of improving student attitudes toward science as well as developing cognitive and psychomotor skills. Incidentally, it will also link objectives, learning experiences and evaluation, nature of students, of course, not excluded.

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The Psychological Bases of Science Teaching

N. Vaidya

Introduction

It is a pity that very little is known in this country about the psychological structure of any one of the school subjects. Science Education at all levels, in this context, is no exception. It must be pointed out straightaway that the elements of unit and lesson plans do not inform the practising teachers about the various outcomes of science education. Principles of teaching like the following : simple to complex, concrete to abstract, known to unknown and easy to difficult, of course desirable to know, do not clarify any psycholigical notions. This sort of criticism also applies to the various approaches to learning : learning from first hand experience, trial and error or success and learning by doing. Even factors like motivation, proper orientation, students' desire for recognition, accomplishment and new experiences including the act of independence to think, and teachers attitude towards his work do not escape this criticism. Further we also do not know specifically, about the conditions (or the operation of outside variables) under which learning takes place maximally. It is, therefore, no wonder that we have not concerned ourselves much with pressing psychology in the service of stimulating cognitive growth among our science students at various age levels. It is a disappointing state of affairs but still in the existing state of knowledge, it is possible for us to teach science effectively

from the view point of psychology in the absence of adequate teaching and learning theories now available.

Functions of Learning Theories

General psychologists have not worked out both extensively and intensively the educational implications of their respective theories. However, the various learning theories currently available must aim at the following functions:

1. They must reflect the nature and spirit of science teaching. Science is to be viewed both as a process (mastery of the various phases of the scientific method, i. e, research operation) and product (mastery of facts, concepts, principles and laws and their application to the problematic situations).

2. They must extend their knowledge and understanding of the teaching learning process under varying conditions. This also includes learning in a group (social situations).

3. They must inform them intelligently (and this involves prediction of behavior as well) about the conditions under which learning takes place maximally.

4. They must be a source of new hunches, hints, clues, ideas, hypotheses which can be tested in the actual classroom situations. This provides them some vogue ideas about assumptions underlying human thought processes.

5. They must reflect a wide spectrum of behaviour, i.e. picking up vocabulary, facts, information, concept formation problem solving (both presented and discovered), critical thinking creative thinking and original thinking etc. If this is not so, result will be disappointing (1).

Concept learning

One of the easiest approaches to teach is to take one concept at a time and develop it through a series of planned experiences which may be in the nature of first hand experiences (activities, experiences); observations (directed or undirected); and making and suggesting suitable inferences hypothesizing and its testing). To quote L. Herbart Mason:

> I must begin by teaching them the ordinary parts of a plant; the stems, the roots, leaves, and buds. After they have learned these, I call their attention to the fact that every leaf has a bud in the axil. This is called an "ordered" pair.
>
> If you will look at a tree with ten or twenty thousand leaves on it you will find that every normal leaf has a bud in its axil. The leaf lies between the root and the bud, and the bud lies between the leaf and the tip. I asked the children to map that relation on a stick. All of them could do it. Thus they can map a concept on a stick. Then I call to their attention that the root precedes the leaf, precedes the bud, precedes tip as you go up the stick to indicate an ordered formula. They had just been introduced to equations two weeks before. One little youngster said, "This is just like an equation." Of course, there are some differences, natuarlly, but none the less, it is a mathematical statement that they have become aware of.
>
> Then we give them a notation to represent these things, r precedes b, b precedes t. Next we say "We want to use this little model, this little map you have made, to discover hidden knowledge." In this first excercise, we give them an ordinary willow stem about four inches long. We selected the stems so that they are just about as thick at one end as the other. We told them, "Place the sticks on your desk according to your model so that the base is on the

desk and the tip is in the air." Two of them missed it; all of the rest were able to do it. Of the two that missed, one was just careless She knew the answer, but the other one was confused. All of the rest of them got it and knew why they were right.

The next thing we gave them was an ordinary white potato and said, apply your formula now to the white potato and see what the potato tells you. The teacher was told she was not to ask them any questions except, What else does the potato tell you? The first question was, "Do you see anything that looks familiar"? One little girl said, "I think I see some thing that looks like a bud." A little boy said, "Oh, that is just an eye." He did us a very great service because he gave us a vocabulary to work with. Then a youngster frantically waved his hand and said, "If the eye of a potato is a bud, according to my model the eyebrow is a leaf scar." He was using his mathematical model to arrive at something that never occured to him before. The next youngster said, "If the eye of the potato is a bud, and the eyebrow is a leaf scar, the potato must have a base and a tip." *He made this deduction by being prodded only to see what else he could discover.*

The teacher then said, "Place the potato before you on your desk so that the base is at your right hand, the tip on the left." There were 39 youngsters and 39 got it right. They could use this model in *the second grade and reach effective answers* (2).

It is an example of *concept learning*. It links mathematics and living bodies in *new, exciting* and fascinating ways. It succeeds to root theoretical notions in first hand experience with rich possibilities of developing additional process skills: questioning, defining the problems, discovering, recording, organizing, planning varied solutions, generalizing, predicting, setting up control experiments, understanding

hidden relationships, making operational definitions and discussing and communicating in precise terms'. To quote Kuslan and Stone :

> Ofcourse, the twigs and potatoes are concrete, in sharp contrast with the molecules and atoms with which other concept-teaching experiments have been concerned. This model which organises such concepts as leaf, axil, bud, root, and tip in a serial order led to the discovery of new knowledge by children so young that their success was completely unexpected. Direct experience with concrete materials seems to be absolutely necessary in order to form the model, but once formed, it is generalizable to new situations (3).

Errors in concept formation do take place. They may arise due to imperfect perceptions, faulty verification, and validation and misplaced over confidence in one's recordings, interpretations and conceptual thinking (Russell). Let us now turn our attention to the learning theories

Consideration from various viewpoints

Let us now discuss the psycholigical bases of science teaching under the following heads

(a) S. R. Theories
(b) Gestalt view
(c) Geneva angle
(d) Strategy of dicision making
(e) Acceleration of mental development

(a) S. R. Theories

These theories give us two concepts, namely conditioning and reinforcement. These two concepts are highly useful for explaining early learning including the pre-school period. Picking up of new vocabulary, symbols and formulae in science and learning a foreign language are other examples

which can be easily explained by the S.R. theories, at the higher secondary stage. However, these concepts do not go far enough to explain advanced processes of thinking when we confirm that the aim of science teaching is not the acquisition of facts and bits of other information but 'to attain the understanding of the relationship which present the answer to the problem' (3). This emphasizes both aspects of science namely process and product.

(i) Conditioned View. Inspired by the studies of Hull, Maltzman has propounded a full description of thinking from the behaviouristic point of view based upon S-R theories. His concept of compound temporal hierachy covers 'divergent trial and error mechanisms and the convergent, discrimination learning mechanisms'. Effect of reinforcement is not strictly confined to a particular member but is supposed to generalize to the other members as well. Mediated generalization accomplished by linguistic responses is a basic notion in his theory. His theory fully explains the role of anxiety, failure to solve a problem and the recurrence of interfering responses. According to him it is quite possible to develop original thinking (common and uncommon uses, say, of an automobile tyre) provided certain suitable techniquee are devised which bring about that type of infrequent of uncommon behaviour relevant to those conditions. His theory, however, fails to explain the wellknown two string problem (Mainer) but still this theory appears to be quite fruitful in the field of problem solving (4).

(ii) **Programmed learning**

Skinner and his co-worker have developed the basic ideas of programmed learning from their

investigations in the area of animal learning and realized the dream of Edward Thorndike and Arthur Gates by constructing a mechanical device which could be successfully used for personal or individualized instruction. The most important notion in his work is that of immediate reinforcement. Skinner has demonstrated that it is quite possible to teach advanced skills to rats, cats and pigeons etc. which they did not possess before the beginning of the experiment by breaking the advanced skill into the smallest bits, and then choosing the most relevant and meaningful stimuli and responses which fit into each other like the various links in a long chain. For achieving these purposes, advanced electric equipment came handy to him. Thus he was able to teach pigeons, for example, to dance in intricate patterns or to play pingpong game till their beaks bled profusely. The activity itself appeared to motivate the pigeons to continue the game for a long time. According to him, classroom learning is deficient because the correct responses are not adequately reinforced at the proper time (5). Thus he arrived at the basic notion of reinforcement (immediate reinforcement and the conditions surrounding it) and applied it with astonishing results in the so-called teaching machines now getting quite popular in some advanced countries like U. S. A., U. K., and U. S. S. R. Consider the following two examples :

(i) Matter is made up of atoms. Table is matter, So table is made up of atoms.

Similarly brick is a matter. So brick is made up of..............

Brick and table are matter. Each of them

occupies space and possesses weight. Therefore matter occupies.............and possesses........... and so on (4).

(ii) A-1 A very important discovery in physics was the natural attraction of objects due to static electricity. *If we rub a hard rubber comb* with a wool cloth and hold it over bits of tissue paper, *the comb will attract* the paper, This attraction illustrates,...... ....Electricity

A-2 At parties, you have seen some-one rub baloons *against a wool rug to make the baloons stuck to the walls or* ceiling. This is another example of... ....

A-3 In *electricity* some *objects* will attract each other. A hard rubber comb rubbed against wall will............... .. bits of tissue paper.

A-4 Still another example of static electricty can be *seen* when a piece of amber that has been rubbed with silk will,.....................small objects.

A-5 Static electricity can also cause object to repel each other. When a comb rubbed through fur is brought *near another comb rubbed through fur,* the combs will not attract each other, but will.................each other.

A-6 Knowing that two rubbed combs will repel each other, you would predict that two amber rods would also...................

A-32 The general rule is that,............*charges* attract and..............*charge repel.*

A-33 The general rule for attraction and repulsion is that.....................

repel and unlike charges
attract or
you could say, unlike charges
attract and like charges repel (4).

Different versions and many variations within the same version are possible depending upon the specific objectives to be achieved, the nature of the pupils and the expertise of the programmer. The pupil himself reacts bit by bit to the whole programme as the amount of information presented at each step is very small. He thus learns what he is expected to learn by the programme without the help of the teacher. The very working on the machine, the varied type of stimuli in the programme and the immediate knowledge of the results continue to motivate pupils to a very high degree. Right responses in the teaching sequence are immediately reinforced. In an ideal programme, a pupil is sure to emit a correct response all the time.

There is nothing wrong with the pupil if he fails to learn. The fault only lies with the programme itself for the pupil must always succeed. A programme is judged quite suitable for practical purposes if above 90 percent of the pupils are able to learn the entire programme.

Programmes so far developed have been criticized on the grounds that they fail to develop literary appreciation, constructive imagination, thinking (critical, creative and original), emotional and artistic sensitivity and in no way at all help a student to memorize a long poem etc. Of course, for the teacher, part of the donkey's heavy load is unburdened to some extent. Controversies still centre around efficacy of errorless learning, (within immediate and ultimate) and desirability of the immediate reinforcement, amount of information contained in the step, the structure of the programme

itself (linear or branching), role of anxiety and frustration (their importance and significance) in learning (Beschki, Waterhouse and Child) and exclusive use of verbal methods alone. Researchers will answer these problems in due course of time but it is still possible to achieve the objectives of teaching by emphasizing programmed techniques and methods if we do not bother ourselves too much wish the above mentioned controversies. Teaching sequence is strenthened provided we know its weakest points and if we choose and use different types of learning tasks and presentation medium suitably graded (maps, pictures, practical work, paper prog-rammes, models and tape recorders etc). In the light o objectives, we can train our pupils to react educatively o their own to these learning tasks. This is a first step toward self education and the imaginative use of programme techniques (not yet done) than programmes as understo and available today show a great promise in the ne future (7).

(b) Gestalt View

Insight From Gestalt psychology, we get two b ideas, viz, insight and productive thought which on c deration appear to be quite relevant to science tea Insight had needed a lot of explanation since Kohler i duced this term on the basis of his well known stu chimpanzees. Its main distinguishing characteristic suddenness of solution, Aha experience, eureka, I found it experience, and click' etc. The opponents concept have attacked and described this term as ' mysterious, antiscientific and accidental' etc. Fig past history of the individual behind this concept. cally speaking, all appear to agree that insight occ there is seeing of the new relationship, a restru the field or an integration of experience. High

quality of the past experience and nature and content of the problematic situation make the experience of insight highly probable. Further, Duncker also attempted to distinguish between analytic insight (reproductive knowledge) and synthetic insight (productive knowledge). As undertaking and inference are present both in successful solution, it is not possible to distinguish solution on the basis of the above mentioned two sub-concepts. This difficulty further increases (as Peel puts it) when Gestalt psychology does not evaluate productive thought. In other words, we can then say that 'the flash of insight is not an evidence of an unusual height to which intelligence has soared but an aptness of the solution suggested'.

Productive Thought

Productive thought implies 'analogy, selection, reassembly, coordination and structuring'. In productive thought, children consider all sorts of hypotheses to solve a problem.

According to Peel, the distinguishing characteristics of Productive Thought are :

(1) It contains an element of forward thinking.

(2) It becomes effective by changing the problem situation materially in order to achieve solution.

(3) Some new problem may be solved by restating them in the light af established explaination.

(4) It always appears when a new problem situation is met.

(5) These situations may be material, social or personal (5).

Dunker investigated the thought process of university students by using practical type of problems which had clear cut solutions. His main aim was to find out how and in what manner the solution of a problem arose from the very

problem itself. According *to him, there is a problem when* one has a goal but does not know how to attain it, there is then 'recourse to thinking'. Two of the world famous problems as investigated by him are mentioned below:

(1) Compensated pendulum. You have seen a pendulum. The slowness or fastness of the pendulum depends upon its length, the distance, between the point *of suspension* and the centre of gravity of the bob. In winter, this length decreases and the clock goes fast and vice versa *in summer*. But *we want the clock to run with absolute* accuracy. How can be this defect remedied? Lastly, we are 'only concerned with the length of the pendulum for the rest, the pendulum may have any appearance at all'.

(2) Stomach tumour. There is a patient suffering from an *inoperable stomach tumour. Radiation at different inten*sities is avoidable The problem is to treat the tumour without destroying the healthy tissues surrounding it. What can *be done*?

He used the case study approach. The subject was asked to speak aloud all the ideas (sensible and stupid) which struck him during problem solving The subject was allowed *to ask question from the experimenter to clarify* his doubts All the responses emitted by the subject were recorded verbatim Lastly the dialogue continued till the problem was solved partially or fully or when the subject gave up Further, Duncker also used other thought stimulating and provoking problems involving a continuous chain of reasoning The following conclusions emerged from his studies

(1) One solution is as good as any other solution so far as the 'way out' of the problem situation is concerned. What is preferred, in fact, is the degree of the acceptance of

the demands of the problem. Extraneous considerations enter into the problem situation when the essential aspect of the problem is not grasped.

(2) Dunker then distinguished between functional solution and the specific solution. The functional solution may be right or wrong. It only reflects the general range of approach or even availability of ideas on a particular problem. . At the specific execution of the solution stage, the problem is simple to fill in the minor details only. He then distinguished between meaningful errors and stupid errors. The former arose in the specific execution of the right idea and the latter ones when the grasp on the problem was either absent or too poor. This further led him to distinguish between organic solution and mechanical solution by the type of behaviour shown by the subjects during problem solving (in the final written from of the solution, this distinction is very difficult to maintain and Duncker is aware of this difficulty). The organic solution according to him, is meaningful, less elegant, long and time consuming where as the mechanical solution is concise and follows a set pattern. Moreover, in the case of an organic solution, one sees clearly the evidence for the analysis of the goal, analysis of the situation or conflict and analysis of the material For instance, Piaget's work on number shows the concept of mechnical solution in the case of children who compute accurately without even understanding the basic ideas (also see John Holt).

(3) Generally speaking, in the case of a successful solution, each response to the problem situation is in fact ne reformulation of the problem developing organically. n prospect, it is the nature of another problem (Concertization of the goal) and in retrospect, the nature of the partial solution to the problem. The formulation of the problem

more productively then implies the emergence of one or more than one functional solutions where a specific statement or a series of specific statements leads to the final form of the solution or solutions.

(4) Solutions learnt mechanically, i. e. without understanding tend to be forgotten in the near future. Past experience then does not guarantee success because the very essential of the problem was not grasped then (6).

(5) Cues and hints are only understood when they approach the 'genealogical line already under-development' which is in conformity with Selz's General Law of Anticipation . "An operation succeeds the more quickly, the more the schematic anticipation of the solution approaches a complete anticipation'. Clues and hints are not understood straight away in the absence of any past scheme approaching completeness.

Implications for Science Teaching

Let us now consider the implications of Gestalt psychology for science teaching.

(1) It visualizes an active role for the learner in his learning process–he is not a passive entity. This implication is naturally linked with self study and self education, an excellent cûlminating point for our educational system in this country.

(2) It discourages the acquisition of facts, concepts and principles without understanding. When seen from a positive angle, it implies that it is real knowledge alone which gives power.

(3) It stresses divergent thinking (see Guilford) that is going far beyond the starting point in one's thinking by

ting up all sorts of hypotheses (open hypotheses) and
ting them against the given data, the demands of the pro-
n or setting up control experiments with a view to exclude
elevant variables. Thus new scientific concepts (insights)
gained through a series of acts of discovery, however
se small may be.

(4) And lastly, as Peel says Duncker has said the last rd on teaching, 'Proceed as organically as is feasible-even the cost of brevity and elegance' (8).

) Geneva Angle

The two personalities of the Geneva School (Jean get and Barbel Inhelder) are now well known all over world, even U. S. S. R. being no exception. Piaget is damentally an epistemoloist (epistemology is a branch of osophy) and he therefore engages himself in studying the mind develops ideas about the environment. The cational implications of his work, of course, immense are dental rather intentional; for he frequently says that he tle interested in psychology and education. About him n be safely said that he is a difficult author to read and rstand, his writings cut across several branches of know-, he is always misunderstood and criticized harshly e puts too many thoughts in one paragraph but also nes too much previous knowledge on the part of his rea-
And reading him always is a revolting experience. sual description of him has deterred many serious minded e to study him at depth.

Ideas

Let us now describe some of his ideas relevant to scie-aching in brief. According to him, there are three dis-periods in the logical growth of a child. These distinct

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setting up all sorts of hypotheses (open hypotheses) an testing them against the given data, the demands of the pro lem or setting up control experiments with a view to exclud irrelevant variables. Thus new scientific concepts (insights) are gained through a series of acts of discovery, however these small may be.

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Basic Ideas

Let us now describe some of his ideas relevant to science teaching in brief. According to him, there are three distinct periods in the logical growth of a child. These distinct

periods which follow each other are universal with reference to Swiss children, these periods are:

(a) Pre-operational stage from 0-7 years.

(b) The concrete stage from 7-11 years.

(c) The formal stage from 11 to 15 (or 16 years)

(a) Pre-Operational Stage

The first two years of life constitute the Sensory Motor Stage. This period is of little educational significance to the science teachers. As the child grows further, one finds that the childs' reasoning is governed by the perceptual considerations of the situation. He markes the judgment as he *sees the situation. His reasoning is transctive, that is, he* reasons from particular to particular. It is intresting to note that he can entertain two conflicting judgments at the same time without any embrassment. Even when the contradiction is pointed out to him, he is quite emphatic about *his statements. Consider the following examples:*

(1) Take two sticks of equal length. The child declares that the two sticks are of equal length. Now displace *one of the stick side ways. The child now declares* that one of the sticks is longer. Do the same thing in the other direction. He again declares emphatically *that* the sticks are of unequal length. Now restore the original condition. Child declares that the sticks are of equal *length as they now coincide point to point.*

(2) Ask the child to take equal amounts of water in two beakers of equal *size. After this, ask him to transfer* these contents in one broad tube and the shallow dish respectively. On asking *whether the two amounts of water* are equal, child declares emphatically that the broad tube contains more water than the shallow dish.

(3) Ask the child to make two equal collections of

coins or pebbles. Now ask the child to throw one of the heaps on the floor over a wider area on the floor. Child, on questioning, declares that there are more coins or pebbles on the ground than in the heap.

(4) Ask the chid to make two equal balls of plasticine. Now ask him to make sausage of one of the balls (or pancake). On questioning, child declares that the sausage contains more plasticine than the ball (the amount of plasticine in the sausage is greater than that of the ball). Now ask him to restore the original forms. The child now declars that the amount of plasticine in the two balls are equal.

According to Piaget, this happens because the child's thinking has not yet attained reversibility. One interesting thing to note is that at the higher ages, the child uses the same arugments to deny the conversation of weight and volume.

(b) Concrete Stage

It is a distinct improvement over the previous stage. At this stage, the child can solve all the above mentioned problems. He now realizes the weeknesses in his previous arguments. But still his thinking is tied to the situation or the empirical data. He does not accept hypothetical data. If he is pressed to solve the problem he criticizes it and brings extraneous factors, which are not at all essential to the solution of the problem, into the problem situation. He also judges problems from their moralistic standpoint before he accepts them to solve. He cannot think when concrete situation is absent. For example, he cannot answer the question: "Edith is darker than Surzane and Edith is darker than Lily; which is the darkest of the three"?

(c) The formal stage

This stage is qualitatively different in the sense that

periods which follow each other are universal with reference to Swiss children, these periods are :

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got its history. Today's getalt has developed during past and at this stage, it is possible for the subject to n and break this gestalt.

Further Piaget says that child develops his cognitive structures. Child cannot assimilate knowlec the corresponding cognitive structure is absent. He then accommodate to the new knowledge. This is knowledge as distinct from true one. He even suggests drill should be based upon understanding. Child's u standing cannot be improved merely through talking. the contrary learning situations should be presented ir a manner so that the child gets enough opportunitie time to experiment and discover on his own, "trying out to see what happens, manipulating things, manipu symbols, posing questions and seeking his own a reconciling what he finds at one time with what he another, and comparing his findings with those o children" (9).

(d) Strategy of Decision Making

Bruner's approach suggests that we live in which is composed of a tremendous array of discri different objects, events, people, and impressions etc consider colour alone, there are estimated to be sever discriminable colours. It is an impossible human give a name to each of the seven million colour di Bruner suggests that to solve the problems createc the human mind categorizes the environment and it. This necessitates the development of concept technically speaking, the 'strategy of decision makir 'strategy' refers to a pattern of decisions in the ac retention and utilization of information which is c ful in solving problems encountered in the environm

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the adolescent pupil now considers the possibilities as distinct from reality. In the concrete stage, reality was dominating, but now in formal stage, possibilities dominate and realities are secondary or are subordinated to it. It is at this stage that the adolescent pupil sets up hypotheses and tests them against the given data by setting up control experiments. This is how he reaches conclusions which are consistent with empirical observations. For example, it is possible for the adolescent pupil to discover the law of inertia himself. He rolls balls of different size on a smooth surface. He finds that, whatever may be the smoothness of the surface, *each* ball stops after some time. If his reasons are recorded and if he is of average *intelligence, his last reason* will not be the force applied to the ball but will be the resistance offered by the surface over which the ball rolls. The nature of the surface is a factor which is outside the following variables, namely, (1) the force with which the ball is thrown, (2) the size of the ball, and (3) the nature of the ball. This is not true only for the law of inertia Other physical principles and laws can also be discovered by the adolescent pupil of average intelligence. By setting up control experiments, *he can identify the relevant variables and eliminate* the irrelevant ones. For example, in the Simple Pendulum Experiment, he can easily discover that the time taken by the pendulum for a swing depends strictly upon the length of the string alone. Other irrelevant facts like the amplitude of motion, the weight of the ball and the force with which it is made to swing are rejected by him through control experiments. In short, the adolescent pupil can *develop* the methods of attack on a problem or learn the *methods of discovering the solution to a problem* with the help of his own logical structures, which he has developed by coming into active contact with the environment. This type of intellectual behaviour does not manifest itself like the hump on the camel's back, all of a sudden. It has

got its history. Today's getalt has developed during the past and at this stage, it is possible for the subject to make and break this gestalt.

Further Piaget says that child develops his own cognitive structures. Child cannot assimilate knowledge if the corresponding cognitive structure is absent. He may then accommodate to the new knowledge. This is false knowledge as distinct from true one. He even suggests that drill should be based upon understanding. Child's understanding cannot be improved merely through talking. On the contrary learning situations should be presented in such a manner so that the child gets enough opportunities and time to experiment and discover on his own, "trying things out to see what happens, manipulating things, manipulating symbols, posing questions and seeking his own answers, reconciling what he finds at one time with what he finds at another, and comparing his findings with those of other children" (9).

(d) Strategy of Decision Making

Bruner's approach suggests that we live in a world which is composed of a tremendous array of discriminably different objects, events, people, and impressions etc If we consider colour alone, there are estimated to be seven million discriminable colours. It is an impossible human task to give a name to each of the seven million colour differences. Bruner suggests that to solve the problems created by this the human mind categorizes the environment and simplifies it. This necessitates the development of concept or more technically speaking, the 'strategy of decision making', where 'strategy' refers to a pattern of decisions in the acquisition, retention and utilization of information which is quite helpful in solving problems encountered in the environment.

On the basis of this approach, Bruner suggests that

science should not be taught as a 'factual subject' but as a 'tool subject'. By the later term, he means that intellectual structures should be found out logically by research workers and teachers of science. This means that the whole of the science curriculum should be built around comprehensive science concepts (intellectual structures) and corresponding learning experiences developed around them. This means or will mean that a good portion of present science content will become redundant. Work on these lines is going on in the U. S. A. We may mention here the work of Physical Science Study Committee on physics, and corresponding work in Biology in U S. A. These courses based on this approach provide training in scientific method and do not replace one set of facts by another just for the sake of newness and novelty (10).

(e) Acceleration of mental development

As environmentalists, it is quite safe for teachers to assume that at least a bit of acceleration of mental development does take place under the influence of the well thoughtout and executed learning situations. Piaget does not deny the acceleration of mental development but at the same time, he is not at all one of its advocates. He has simply investigated laws of mental development and does not at all place any restrictions on the magnitude of development, that is, mind may evolve high and even higher structures in the times to come (evolutionary concept of mind). Environmental pressure may compel the organism to adapt quickly to the environment, reflecting in the process the cultural differences. Piaget allows the influence of culture on mental development. On the other hand, there are psychologists like Vygotsky (instruction precedes development), Z. P. Dienes (if school syllabus is organized on the following four principles like dynamic, perceptual variability, mathematical variability and the constructivity); Stendler (use of well

ructured scientific mathematical experiences); Bereiter and ngelman (concentration on drill very early for those who re really disadvantaged in life) and others like J. Bruner, Benjamin Bloom and J. Mcv. Hunt who believe in the cceleration of mental development. However, Lovell, Ogilvie nd Dowdell do not favour the acceleration of mental evelopment hypotheses. It is, therefore, safe to conclude hat a very potential and fruitful area of research awaits nvasion by the educational psychologists in general and the ractising science teachers in particular (11).

Before we conclude, it will be of interest to mention hat increasing emphasis in science teaching is being placed n the teaching of scientific concepts rather than facts. Resnick emphasizes teaching the big idea of science (12). Bruner advocates fiercely that science should be taught as a tool ubject. With referencs to mathematics (modern) teaching, Skemp has propounded a schematic learning theory. According to him, schema has a dual function viz, to "integrate nd organize knowledge within itself' and also to be an indispensable mental tool for the understanding and learning of new knowledge". Understanding is characterized only by this process of assimilation which if absent makes the whole business of learning only rote memorizing and isolated pieces of knowledge.

Secondly, there is a difference between a fact and a concept. One cannot teach conepts to children simply by telling or talking. On the other hand, child froms the concept only when he himself extracts it form a 'suitable group of experience' which is the business of the teacher to arrange. Skemp further adds that it is not a case of trial and error learning for great care is needed in arranging the group of experiences manifesting a given concept only, that is, "parts relevant to the concept must remain the same, while the irr-

elevant parts cancel out". Lastly, Skemp also emphasizes that children must discuss and argue about the various pros and cons of the problematic situations. The most opportune time for the teacher to intervene comes when children in a group fail to resolve their conflicting opinions (13).

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Role of Methods in Science Education

N. Vaidya

Introduction

In Handbook of Research on Teaching, N. L. Gage says that 'teaching is an intriguing, important, and complex process'. 'Because it is intriguing, it attracts scientific attention.' 'Because it is important, it merits careful research.' 'Because it is complex, research on teaching needs many-sided preparation' (1). We are still at the beginning of the first stage in our country because teaching methods are about to receive scientific attention which they deserved in the past. Of course, there has been lately wide spread awareness of the same But it is still true that they continue to be opinion based rather than hypotheses setting and testing in character. The word method has a latin origin which means 'mode' or 'way'. Here, it means methods of delivering knowledge and transmitting of scientific skills by a teacher to his pupils and their comprehension and application by them in the process of studying and learning science. Right at the very beginning, it may be pointed out that teaching learning is a very complex process which comprises teachers students, instructional and illustrative material and the permissive atmosphere within the setting of a school In a highly restricted sense, it means what to teach and how to teach it. Regarding the latter, I. D. Zverev considers knowledge and skills as the basis of classification of methods resting on word (narration), object (image) and action (motion) (2). Thus in his scheme, three corresponding classifications of methods are oral, observation and practical. We have detailed his classification as follows:

(a) **Oral Methods**

(i) Talk
(ii) Narration
(iii) Lecture
(iv) Work at a book

(b) **Observation Methods**

(i) Demonstration of natural objects
(ii) Demonstration of charts and models
(iii) Demonstraion of slides and films
(iv) Chalk Drawing

(c) **Practical methods**

(i) Conducting Observations
(ii) Conducting experiments
(iii) Conducting relevant laboratory work

Through oral methods (especially talk and narration), a science teacher can carry on intelligent and meaningful dialogue between himself and his pupils in the classroom or even in the science laboratory. He can develop two efficient techniques of teaching, namely, question answer and discussion if he bases his oral methods of teaching on his pupil's first hand (including background) experiences. Under guidance, even work at a book can be made a fruitful activity in the teaching learning process comprising retelling of the text, explaining of pictures and sketches, putting and answering questions on the pupil's part, working out a plan to the text, looking for additional facts at the school or the town and village library, and conducting an observation or experiment in accordance with the instructions given in the text book (2). The weakness of this classification is that it does not inform the science teachers about the psychological basis of science teaching for different groups of children at various age levels throughout the school.

condly, unfortunately we do not follow any such classi-
ation of methods in our country.

Problem to be Attacked (Functions of Methods)

Very few people in the field are aware consciously and plicitly about the functions of various methods of teaching day to day classroom teaching. Largely speaking, we d to follow the traditional approach rather than show great ncern for examining our traditional modes of thinking and ing. The result is that any teacher can discern easily his ttern of behaviour if compelled to do so To quote N. E. allen and Robert M.W. Travers these are .

1. Patterns derived from teaching traditions
   (Illustration : A teacher teaches as he was taught)

2. Patterns derived from social learnings in the teacher's background,
   (Illustration : A teacher reinforces the behaviour of pupils so as to develop a middle-class ideology.)

3. Patterns derived from philosophical traditions.
   (Illustration ; A teacher teaches in accordance with the Froeble or Rousseau tradition.)

4. Patterns generated by the teacher's own needs
   (Illustration : A teacher adopts a lecture method because he needs to be self assertive).

5. Patterns generated by conditions existing in the school and community.
   (Illustration , A teacher conducts his class room in such a way as to produce formal and hostile

disciplined behaviour because this represents the pattern required by the principal.

6. Patterns derived from scientific research on learning (3).

All the teaching methods in vogue fall into these categories. We cannot judge the superiority of one method over the others in the absence of information available on 'the patterns derived from scientific research on learning'. In the present existing state of knowledge, we can only say that whatever methods and approaches to teaching we employ, they must serve fully the aims and objectives of science teaching and also at the same time reflect the major trends of the scientific revolution going on in a big way in our times. Or to put in other words, all methods, techniques and approaches to teaching, either in isolation or in combinations, should provide ample opportunities to the pupils for realizing the process objectives of science teaching which we have already discussed elsewhere in this book.

Their overall objective is to develop reflective atmosphere in the classroom and the laboratory. It is painful to note that in a survey report on Physics Teaching, we found that the physics teachers hardly use any variety in teaching like, teaching in a wider setting, discovery approach to science teaching, use of problem solving procedures and teaching through individual and small group projects are completely absent. It is of interest to mention our evidence in this connection.

Approaches to teaching

The responses indicate that physics teachers hardly use any veriety in the methods and approaches in their day to day teaching. They do not use any particular method. Lec-

ture cum demonstration method appears to be the most popular. Other methods used are mentioned in the table given below :

	Approaches to teaching	*Frequencies*	*Percentage*
1.	Demonstration cum lecture cum illustration.	15	37.5
2.	Based upon Herbartian steps.	13	32.5
3.	By group introduction and then removing (students) difficulties as they arise.	5	12.5
4.	Relating scientific facts to daily life experiences.	3	7.5
5.	Questioning teachnique.	3	7.5
6.	Making use of the previous knowledge of the students.	3	7.5
7.	P. S. S. C. approach.	3	7.5
8	Laboratory and demonstration method.	2	5.0
9.	Inductive, deductive, analytical and synthetic approach	2	5.0
10.	From known to unknown.	1	2.5
11.	Posing a problem question.	1	2.5
12.	Through notes.	1	2.5
13.	No response given	1	2.5

It is clear from the above table that in their approach to teaching of physics, new ferments are completely lacking. Teaching in a wider setting, discovery approach, use of heuristic method, historical approach, teaching through individual and group projects and lastly the student-teacher planning, for example are completely lacking in a big way. This situation can improve only if we improve the average quality of the teacher through in-service education, care to

develop educational research on methods, make educational system less rigid and set high standards of work (4).

Methods of Teaching Currently Available

The following methods of science teaching at the higher secondary stage have varying degrees of relevance for us in this country :

(a) Lecture Method
(b) Demonstration Method
(c) Lecture cum Demonstration Method
(d) Problem Solving Methods/Discovery Approach
(e) Project Method
(f) Historical Method
(g) Other Methods and Procedures.

These methods are discussed theoretically, largely speaking, at the teacher training institutions. Students do not gain any proficiency worth its name on (d), (e), (f) and (g) methods. Attempt has been made in part III of this book to reflect the role of methods of science teaching in the scientific education of our young boys and girls in the context of parts I and II of this book. A critical review of the current states of the role of methods in science teaching will suffice.

Concluding Statement

In our discussion, we have not referred to *methods* like inductive, deductive, analytic, and synthetic, the reason being that we believe that the inherent ideas underlying them can be easily kept at focus in the development of the lesson without suffering any loss of efficiency in the methods currently avaiable. Historically speaking, science teaching began in England with lecture and demonstration methods.

h universities neglected science teaching. The scientific veries, on the other hand, were made by amateurs like ndish, Priestly, Watt and Herschel, etc. In 1884, H. rmstrong showed his extreme dissatisfaction with de- tration method by saying that 'listening to lectures uced little abiding effect.' Project method is the product e twentieth century and historical approach to science ing was developed in a big way by Conant and others e 1950s. Of course, valuable, it has not caught up the teachers.

We really do not know which of the methods is the All methods appear to work equally well when young ren exhibit too much eagerness to learn science. The n for this is that the research on thinking is not yet usive enough to suggest an answer. General experience, ver, tells that pupils differ from each other so they differently through different methods, individual ex- nce is superior to the demonstration method if one ders the long term consequences of the lesson, when d on marks, pupils do equally well when taught by method as they do when taught by the other (individual demonstration); those methods which demands reflection ever, small it may be) on the part of the student, and , methods which are based upon concrete experiences xamples and individual and group conscious

This, however, does not exhaust the methods available the teacher. Examples are : documentation method s, engravings, diagrams, films. etc.) debating, audio l methods and individual and group methods. Their as not yet begun in our country but they offer immense bilities for capitalizing pupils' experiences for a high of proficiency in science. A student who is consulting tionary, map, supplementary material and interviewing

important people from all walks of *life* (*of course, relevant to the problem under study*) is documenting himself. He is thus face to face in a true-to-life situation and is in his own way and at his own level, he is trying hard to assemble documentary material which he studies and collates in order to show the interdependent links. Debating which as a method of teaching is quite popular in Englih schools develops '*integrity in research work, confidence in expressing well founded convictions* and courtesy in discussion'. The educational value of *this approach increases if debate is closed* 'with a constructive summing-up of conclusions'. Audio-visual methods are another example which bring current information and teachniques on the cheap into the classrooms. The twentieth century student 'may turn a deaf ear to a school which deprives him of such attractive *means of receiving information*'. *Coordinative methods* (*field of interest* method) awaken student's interest in science and enable *him* to discover hidden relationships, make and apply judgements, to see the phenomena 'in their true inter-relations rather than presenting them in the form of artificial analysis and to clarify theoretical ideas through firmly grounded analogies'. For a teacher, even individual and group methods have some relevance. Through these methods, he can reach *effectively those who need his help*. In an overcrowded classroom, they *feel ignored and consequently fail to be at* ease and supported in the school. *A change for them could* be given to make good the loss is *permanently lost*. What is in store for them due to this neglect is a general knowledge to all of us in this country.

It is really disappointing to record that in this country we have hardly gone beyond the chalk-talk method. Possibly, we have not made use of *concreate methods of* teaching because we have not yet *developed sufficiently* both economically and industrially. This situation can no longer

erated in the country for we are now having crash ams for the economic and industrial development of ountry. The job for us is clear. We must develop nethods of teaching which suit us by even reconstructing ducational system afresh. Kothari Commission has d us a bit in this direction but much needs to be done rrying out research on methods on a large scale. not suggested that we should not benefit from foreign rience in this area of work.

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Evaluation and Testing in Science

S. C. Dash

1. The Examination Reform Movement In India

The Background

1. Increasing the content coverage in question papers.
2. Increasing the proportion of thought-provoking questions.
3. Increasing the proportion of short answer type questions.
4. Introducing a fairly good proportion of objective-type questions.
5. Abolishing overall options.
6. Having equivalent internal options (when provided).
7. Getting detailed marking schemes with model answers.
8. Undertaking the analysis of pupil's responses as a recurring activity after every examination to provide guidance to schools and paper setters.

Ambitious ? Certainly not ! The Chairman and Secretaries of the Boards of Secondary Education of the country who met in a conference, the eighth of its kind, at Ajmer from December 27 to 30, 1967 call this the minimum programme of examination reform and certainly expect many more changs in much less time. We have become impatient, we ought to be. We cried for three quarters of a century for some change. But it was all cry in wilderness. The story of examination reform in India started only a decade ago.

The Radhakrishnan Commission (1949) expressed its

strong distaste for the present system of exmination in the following words :

"If we are to suggest one single reform in University Education, it should be that of examinations" (1).

The Mudaliar Commission suggested a detailed and improved scheme of examination.

With this the 100-year-old examination system which was a British legacy approached its last days and the All India Council for Secondary Education which was established in 1955 took up the matter of examination reform. At the instance of this Council a seminar on Examination Reforms was held at Bhopal in 1956 which made valuable recommendations. Dr. B. S. Bloom of the Chicago University was then invited to this country for examining our examinations and for suggesting measures for improvement. The Chairman and Secretaries of the Boards of Secondary Education of the Country met in their first conference on examination reform in 1957 and, lastly the Central Examination Unit was born in 1958. Quickly came the State Evaluation Units and, thus, the much needed machinery for examination reform was set up in the country. In 1966 the Central Examination Unit was merged with the Department of Curriculum, Methods & Text Book and the new Department of Curriculum and Evaluation was constituted. Now it is again rechristened as Department of Text books at the N. I. E.

The Problem

What was wrong with the examinations ? The number one charge against it was that it despetically controlled the school practice and thus, gave our educational system a perverted look. We taught of examining and taught as dictated by examination. Thus the 'good servant' was allowed to become a 'bad master'.

Examination is nothing but collecting and interpreting evidences regarding growth status with a purpose. The system had hardly any purpose. If it had any, it was not related to the aims and objectives of education or to the needs of students, parents and the community.

The tools employed were inadequate and faulty. They did not satisfy the criteria of satisfactory measuring instruments. The evidences collected were one sided. They looked at the examinee from one direction and ignored the rest. Thus, even though the object was multidimensional we were content with the measuring of one dimension (subject knowledge) and described and certified him on the basis of this. How long could the falsehood continue in the name of truth! To be precise our examinations lacked the following:

1. Objective-orientedness.
2. Comprehensiveness.
3. Objectivity.
4. Reliability.
5. Validity.
6. Accuracy of analysis and interpretation.
7. Usability.

What is most unfortunate is that inspite of all these serious limitations the examination system had immense prestige and its verdict was honoured as the words of God.

The Programme

The ten-year programme formulated under the advice and guidance of Dr. Bloom envisaged the following:

1. The setting of significant and realistic purpose and goals of learning.
2. The in-service training of teaching personnel;

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2. The in service training of teaching personnel;

3. The development of internal and external evaluation procedures to serve these purposes.

These are the goals to which the evaluation movement of the country has been geared during the last ten years. To be more precise the reform movement has the following major objectives:

1. Clarifying the educational objectives in the various areas of study.
2. Relating evaluation procedures to the objectives and to the teaching programme.
3. Constructing test items based on different objectives with a view to measuring them in a pure form.
4. Planning a test or a question paper.
5. Increasing the comprehensiveness of the evaluation system by improving the present tools and by employing other tools and techniques.
6. Improving the external examination and reducing its undue weightage.
7. Improving the internal assessment procedure, giving it more importance and making it serve education in an effective way.
8. Increasing the comparability of examination results/scores.
9. Improving the objectivity, reliability, validity and usability of examinations and tests.
10. Improving practical examinations in science subjects.
11. Improving the scoring, analysis and interpretation of examination marks.
12. Improving the system of certification.

The task is certainly heavy and it demands continuous and well-planed efforts and the state units have done a

good job within a very short span of time and the new concepts have been widely spread and accepted. State Governments, Boards of Education, Teacher Training Institutions, educationists, administrators and teachers are now conscious of the limitations and actively collaborating in the planning and implementations of various schemes.

The Chairman and Secretaries are meeting almost every year to review the work done and to formulate future plan of action. The staff of the training colleges, a large number of teachers and paper-setters have been oriented. Intensive training courses are being organized. With a view to create a cadre of specialists in evaluation, research projects are being undertaken at different levels for diagnosing the weakness in programmes. Attempt is being made to develop diagnostic tests, objective-based test items and unit tests, and suitable literature on the topic. Schemes have been prepared for improving the practices of teacher training institutions.

The Progress

It is difficult to give a detailed account of all the achievements in our multi-dimensional approach to examination reform involving different stages of education, categories of functinaries and aspects of the educational programme and plunging the entire country of the size of a continent into the movement. Our progress is so quick that the report of any day will be outdated the very next morning. However, some significant achievements can be listed as follows:

1. The ideas have been widely accepted and the resistance to change has been lragely overcome.
2. A large number of persons have been trained in framing test items and paper-setting.
3. A pool of test items, unit tests and other tests has been developed.

4. The field has been flooded with evaluation literature.
5. Board examinations have changed in their character by *improving the questions* and the certification procedures.

The nature of change and the depth of reform is bound to vary from place to place and stage to stage in a sub-continent like *ours which is committed* to the democratic way of life. We have states like *Rajasthan* which have gone ahead with their bold experiments and we have states like Orissa which have so far preferred the pleasure of traditional ways to the apparent dangers of the untrodden path. *But these imbalances and differences* are *characteristic of all aspects of our growth and are only* temporary.

II. Problems of Evaluation in Science

The general policies and programmes of examination reform have touched the system in respect of science too, and the following changes have come in with respect to the Board examinations in science in one state or the other.

1. Introduction of objective questions.
2. Introduction of more of short answer questions.
3. Introduction of Internal Assessment.

The Present System

With the above changes the present system of examination in science can be described as follows.

1. At the High School stage, in *most* of the states of the Eastern Region, there is only *one* theory paper in science carrying 100 marks without any provision for practical examination. In Bihar,

however, there is some specialization and there are four papers. Physics, Chemistry, Biology, and Mathematics. Eighty percent of the marks are allotted to theory and twenty percent to practical.

2. At the Higher Secondary stage both theory and practical examinations are held. In Bihar twenty percent of the marks are set apart for practical whereas in Bengal the percentage is 16 2/3.
3. The theory examinations are conducted externally. In Bihar the system of internal assessment was introduced few years back but has subsequently been discontinued. In Bengal forty percent of the marks in practical is set apart for internal assessment whereas in Bihar marks are awarded by the external examiner only.
4. In some states viva-voce forms a part of practical examination whereas in some other states only experiments are given to be performed.
5. The questions are mostly of essay type Short answer questions are, however, becoming popular In Orissa ten percent of marks are set apart for objective tests
6. A good number of alternative questions are provided and in some cases the total number of questions given is almost double the number to be answered.

This analysis leads to the conclusion that even though ve have had a large number of workshops, conferences and eminars during the last decade for re orienting our examiation policy the discussions have not in all cases led to ound decisions. Therefore, the defects of the system of valuation now in vogue are almost the same as talked about en years back. They can be listed as follows.

1. It does not assess pupil's growth in respect of all the objectives of science-education.
2. It does not give due weightage to the various areas of the course-content.
3. Questions encourage objectively in assessment resulting in unrealiability of scores.
4. Only a few questions have to be answered which decreases the reliability of the test results.
5. Grading of pupils is done mostly on the basis of one external examination and the work done by the pupil during the school years and his achievement in previous examinations are almost ignored.
6. Pupil's participation in science club or other activities in which his interest, ability or attitude get scope for expression and growth is not taken into consideration.
7. A large number of alternatives reduces the comparability of the scores and disturbs the correct ranking of individuals.
8. The classification of students does not take into account the difficulty level of the question paper, the pass mark being always fixed.
9. In some states there is no examination of practical skill at the high school stage.
10. The distribution of marks on the different parts of the essay question is often given to the examiners but the students are not aware of this distribution of weightage.

Evaluation of Reformatory Measures

In view of all this, enthusiastic workers in the line

inly feel that the progress of examination reform very slow. This is probably due to the fact that for change has not been properly appreciated by rity of the policy makers. As a matter of fact and educationists still express doubt regarding the y of the new system. From his experience the els that this attitude is mostly due to lack of knowledge of the newsystem which is often equated introduction of objective tests of simple type based l functions of a lower order like recall or recogni- his poor knowledge coupled with a conservative has resulted in a recationary attitude against the ion reform movement in some cases.

problem which is of great concern for the movement back received by some of the reformatory measures. abolished the system of internal assessment. In he system was intuoduced in the Pre-University ion. But after a few years it was discontinued. rs contributing to the failure of the system should be studied.

other factor which strengthens the reactionary force sentation of the new system on its simplest form poses its weakness rather than the advantages, and he formation of a distorted image. It appears to ay system without having the power of measuring er mental processes and complex educational

ns

e problem in examination reform is, therefore, to expose the limitations of the old system and to n the minds of educationists and workers at all aith in the superiority of the new. This can be

done by conducting studies on the reliability and validity of traditional examinations and giving wide publicity to them and introducing more complex, thought-provoking objective type tests and items in the various examinations.

The suitability of internal assessment in the conditions obtaining in our schools should be carefully examined. Theoretically speaking it is highly desirable and yields more reliable results. But there are many weaknesses in our system which might render it ineffective and unreliable. Some of the reasons are as follows :

1. There is no attempt in our schools to assess pupils' growth frequently and correctly. The examinations are few and far between. They are also conducted in a way which would rarely yield satisfactory results.

2. The records of pupil's growth in respect of various educational objectives are not properly maintained.

3. The practice of private tuition mav contribute to the unreliability of marks and ranks

4. The general tendency, among a section of teachers, to push up their students result in greater frequency of scores in the upper bracket and might distort the true scatter of scores. In other words there might be a tendency towards the undue increase of the central tendency and decrease of the variability.

5. Because of subjective teachniques of assessment and lack of uniform standards the scores of different schools will be less comparable.

In consideration of all this, it is not wise to introduce e system in haste. Before introducing this the school aminations should be reformed. It is satisfying to note at the Extension Services Department of the Central stitute of Education in collaboration with the Central amination unit initiated a programme for improving the me examinations of twenty Higher Secondary schools near elhi. Techniques should be devised to record the progress pupils in terms of the various instructional objectives and tcomes. If the internal assessment mark is derived from ese records the influence of undesirable factors will be inimized.

Since experimental skill is one of the most important tcomes of science introduction, even at the school stage, is desirable to have practical tests in the Board Exami-ation.

Ways and means should be devised for improving e quality and precision of practical examination. The periments conducted in Rajasthan by the Central Exami-ation Unit has thrown light on the matter and the Board s decided to reform the system with effect from the current ear.

Emphasis should shift from objective type questions questions based on instructional objectives. The various bjectives should have their due weight in the question aper.

The present situation demands a bold adventureous ttitude for breaking away from traditional lines. We can-ot afford to be complacent in a matter which decides the te of millions of pupils and which ultimately affect the fficiency of the machinery in administration, industry nd all other areas of the world of work.

III. Characteristics of Good Evaluation System

1. The evaluation system should be geared to well defined goals. The purposes for evaluating, the use to which the evaluation results will be put are basic considerations in the planning of evaluating programmes. This decision will influence the nature of data to be collected, the tools and techniques to be used for the purpose, the way in which *the responses are to be analysed* and reported. If a technique or tool serves the purpose for which it is employed it is said to be valid.

2. To be valid the evaluation programme has to be comprehensive. *It cannot afford to neglect one side of the* traitor aspect being measured. Comprehensiveness in the domain of achievement has to be thought of in terms of the various areas of study and the different dimensions of growth. Comprehensiveness may also be thought of in terms of the use of a variety of appropriate tools or methods for collecting relevant data of different types.

3. The evaluation technique or tool should yield dependable results. Even if it is employed on different occasions, of course within a reasonably short interval, its results should help us in forming the same image of the test. This *quality of a test is called stability* or commonly, reliability. But reliability is often used as a genuine term and includes other concepts.

4. Reliability demands that a test should be able to be *scored in an objective matter.* Subjectivity introduces error into evaluation results

5. The techniques or tools *should have practicability.* If time, money or other factors make its use impossible, its otherwise high quality is of no avail.

Evaluation is a continuous process. Looking at the individual at intervals of 6 months or one year is not enough specially in the field of achievement If we aim at knowing the status of the individual at that specific time we may be satisfied with one examination at this stage. But in educatian examinations serve the more important purpose of improving practices, increasing rate of growth, diagnosing weeknesses, strengthening the good elements, motivating learning and so on. Thus, more frequent examinations are necessary and, in the ideal case, it should be a continuous process as in education.

'. Evaluation has to be a co-operative process if it is made continuous and if comprehensiveness is increased Since the sources of data will be many and time of data collection is not fixed we have to depend on different persons and agencies for gathering all relevant data.

3. Good evaluation procedures do not end with obtaining scores. The analysis process that begins after this, the uses of the results in a variety of ways, the comparison of results etc. are more important in evaluation.

Formulation and Analysis of Educational Objectives

Modern evaluation procedures differ essentially from the traditional system in their emphasis on instructional objectives and outcomes as the basis of test construction. The suggestion of the American educationist Tyler marks the begining of this new approach in 1931. But it took two decades to realize the implications of his suggestions in the scientific development of evaluation tools in the field of achievement. Bloom's 'Taxonomy of Educational Objectives' in relation to the congnitive domain appeared in 1956. In the same year another important book entitled 'Speciman

Objective Test Items' was also *published* by *Gerberich* and this presented a different system of classifying educational goals. Even though Bloom was directly associated in the planning of the evaluation *movement in this country* Gerberich's classification had more influence on the Indian evaluation workers. The two classifications are as follows :

Bloom's Classification (Cognitive domain only)	**Gerberich's Classification** (Three domains)
1. Knowledge	1. Skill
2. Comprehension	2. Knowledge
3. Application	3. Concept
4. Analysis	4. Understanding
5. Synthesis	5. Application
6. Evaluation	6. Activity
	7. *Appreciation*
	8. Attitude
	9. Interest
	10. *Adjustment*

Gerberich's classification refers to the three domains-cognitive, conative and affective. In the early stage of examination reform in India (from 1958) emphasis was given on two instructional objectives Knowledge and Application. Therefore, in the Workshops, Seminars, and other courses organized during that period these two objectives were analysed and test items were constructed for each. This is reflected in the Indian evaluation literature published so far. But quite recently attempt is being made to formulate and analyse all the possible objectives and the following classification has more or less emerged as a result of this attempt.

1. Knowledge
2. Understanding
3. Application

5. Interest
6. Attitude
7. Appreciation

Thus, there is no uniformity or agreement in the classification of instructional goals. Another author, Gronlund has presented his own classification in 1965 which follows the Taxonomy and Gerberich's list in certain respects but differs from both of them. Thus there is a good deal of confusion. The confusion becomes still more prominent when we see that some words have been used by different authors to mean different things. One example is regarding the nature of 'Understanding'.

Specifications

For clarifying and for defining the scope of different words representing objectives they should be broken down in terms of behaviour. This enables us to look for appropriate evidence for the evaluation of objectives. This analysis forms the basis of the concept of validity not only in achievement but in other intellectual and non-intellectual areas.

Construction and Standardization of Tests

Planning the test

A. Purpose

The first point is to define the purpose of the test. A test may be used for diagnosis, prognosis, knowing the status of a group or an individual, comparison of individuals or groups. It may be used for one class, two classes or more. It may be used for one school system or more. The nature of the items and the quality of the test will depend

on this decision regarding the functions or uses of the test.

B. Content

In achievement tests content has to be defined in terms of the objectives of instruction and the areas of study. So the objectives to be covered and the weightage to be given to each objective have to be decided. Similarly the weightage to be given to the various chapteres of the book or aspects of the curriculum has to be fixed. This content-objective analysis may be shown in a two-dimensional chart which may be called the blue-print of the test.

C. Other details

The following factors may also be considered at this stage.

1. Types of test-items to be used and weightage to each. This may also be shown in the blue print and in this case the blue print will be a three dimensional chart.
2. Scoring scheme.
3. Length of the test.
4. Time
5. Arrangement of test items.

2. Preparing the Test

The objectives included should be broken down into behavioural specifications and test items should be constructed. The number of items to be written should be more (roughly 1½ times) than the number to be finally retained. Care should be taken to prepare good items of different types.

3. Trying out and Item Analysis

The preliminary test has to be administered on a

representative sample, of adequate size (200 to 400). The responses are to be analysed with a view to determining the following :

(i) difficulty level of each item.
(ii) discrimination index of each item.
(iii) weaknesses in items.

4. Selection of Items and Final Trial

Items have to be selected on the basis of the above analysis. Too easy and too difficult items and also items which are poor in differentiating the good students from the poor are eliminated. Items with certain weaknesses if retained are slightly modified. Items are selected according to the blue print and are arranged according to a scheme (difficulty, item-type, objective etc). The final test, thus arrived at, is again administered on a very small sample (10-20) to find out the time required and to eliminate weaknesses if any.

5. Final Administration, Analysis and Derivation of Norms

The test has to be administered on a representative sample the size of which will depend on the nature and purpose of the test. Achievement tests for a single grade may standardized on a sample of at least 1000.

The scores should be statistically analysed to determine the nature of :

(i) Distribution of score.
(ii) Measures of central tendency.
(iii) Measures of variability.
(iv) Skewness and kurtosis of the distribution.
(v) Reliability and validity, and
(vi) Norms of the appropriate type (age norms, grade norms etc., local, regional, national norms).

Some of the findings may be graphically presented in the from of frequency polygons, histograms, cumulative distribution curves and ogives. A scheme for the reporting of results may be suggested (*profile*).

6. Implications of Standardization

Thus standardization implies the standardizing of (a) *content*, (b) administration, (c) scoring and (d) *interpretation.*

Reliability and Validity

Reliability

The term reliability has been used in educational literature as a generic term. It mainly covers three concepts; (1) stability, (2) internal consistency and (3) inter-form consistency or equivalence. Since the concepts of consistency and stability are different from each other and refer to two distinct properties of the test the use of the word reliability for representing the two concepts is often a source of confusion. Some recent attempts at reorganization of concept have increased the confusion.

The following methods are generally employed for obtaining the reliability coefficient of tests.

Type of reliability	Method
Stability	Test-retest
Consistency	Split-half
Equivalence	Kuder-Richardson
	Parallel froms method.

The stability coefficient of good tests should be not less than 80. In many cases this value is as high as 98. But tests with lower values are not useless. If a test is

meant for group comparison a reliability coefficient of .50 is tolerable But the Kuder Richardson coefficient (homogeneity coefficient) may not be necessarily very high. When we include items in an achievement test for measuring different objectives there is deliberate attempt to introduce heterogeneity The split half correlation in such cases is likely to go down unless special care is taken in obtaining two equivalent halves.

Validity

The term validity has never been less confusing than the term reliability. The term covers many different concepts; concurrent validity, construct validity, face validity, content validity, logical validity, statistical validity, empirical validity, predictive validity, rational validity, factorial validity, intrinsic validity, etc. In order to avoid this confusion recently there has been some agreement to report only 4 types of validity-content, predictive, concurrent and construct.

Validity coefficients are not expected to be as high as reliable coefficients. In case of achievement tests content validity is of primary concern.

Review of Achievement Tests in Science Standardized in India

The first Mental Measurement Hand book for India appeared 2 years back containing particulars of 326 tests. Of these, 100 tests are in the field of intelligence, 96 achievement, 60 aptitude, 15 interest, 45 personality and the other ten are placed under miscellaneous. The number of tests in science is as follows.

Subject	Number of tests
Chemistry	3
Hygiene	1

Physics	4
General Science	8
Biology	1
Total	17

But the above list is incomplete and many tests developed in many languages in many parts of the country have been omitted. To give one example, 10 achievement tests in science constructed in Oriya have not found place in the Handbook. Most of the tests included are the out comes of M. Ed research. Some tests have been prepared by Guidance Bureau, Departments of Education or Research Departments. Most of the tests are not properly standardized. Some are incomplete and norms are not available. In some cases the sample size is small (200 or less). Tests are generally not published and available for use The tests are meant for the following classes.

Class		No. of tests
VI	...	2
VII		3
VIII	...	11
IX	...	3
X		5
XI	....	1
XII	..	1

Only one of the tests is properly standardized. Its particulars are as follows.

Title—Attainment Test in General Science for Delta class.

Author—K. N. Saxena.
Class—VIII
No. of items—100

Time—45 minutes
Sample—2190
Reliability—K. R.—15
Validity—·46 (criterion not indicated)
Norms, Key, & Manual—available
Price—Rs 0.75 per manual & Rs 0.30 for each copy of test booklet.

Test Development for M. Ed. research

As indicated earlier M. Ed. research has contributed significantly to test development in India. Hundreds of tests are the outcome of this research. But most (if not all) of these tests are not properly standardized. This is probably due to lack of institutional planning. Test development is a long, laborious process and it is impossible on the part of one student to complete a test during the few months at his disposal. If the work is properly planned and carried on, a continuing basis and if arrangement is made to utilize the tests in different ways, many of our problems may be solved. Some suggestions for this are given below.

1. Each student should not be encouraged to prepare a new test. Some of them may be asked to [illegible] and standardize tests done earlier. For this the [illegible] of the test [illegible].
2. [illegible]
3. [illegible]
4. [illegible]

5. The use of these tests should be popularized through the extension services and through ex-students.

Test Construction And Factor Analysis

Factor analysis is a method of analysing the inter-correlations among a number of tests with a view to finding out or extracting a few meaningful factors which can explain the large number of correlations among tests. Factors are hypothetical structures which are different from the concept of faculties. The factor analytical approach is in conformity with the faith of scientists in general that an unlimited number of phenomena can be explained in terms of a limited number of concepts or constructs.

Correlation Coefficient and Factors

Factors are postulated to be the primary sources of variation in overt behaviour. Therefore, the correlation coefficient becomes the result of such factors. If two tests possess one factor to the extent of a, and x respectively the correlation between them will be ax If there are two common factors which are possessed by them to the extent of a,b and x,y respectively then their correlation co efficient will be $(ax+by)$ Thus their is a mathematical relationship between correlations and the common factors and the later can be derived from the former.

Factors Analysis & Psychological Constructs

The first psychological construct arrived at by the mathematical process of factor analysis was the 'g' factor of spearma. His method was subsequently modified by Thurstone who extracted a number of factors from the table of inter-correlations. The factors identified by him in

ect of intelligence were verbal ability, word fluency, nerical, Perceptual Spatial ability, Memory, Reasoning. se factors are supposed to be independent of each other. rstone constructed tests to measure each of these ors in pure form. Thurstone's researches replaced the imensional concept of intelligence by a multidimensional and led to the development of factor tests in intelligence. larly Cattell's analysis in the field of personality resulted number of personality fsctors which led to the develp- of factor tests in the this area

The above analysis indicates how factor analysis has d in clarifying and defining some psychological ructs and in constructing tests to measure them. In ield of achievement similar analysis may help in the ification of such factors.

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Research in Science Education

Willard J. Jacobson

Science Education Research is the systematic study of problems related to education in the sciences. In these studies use is made of the methodologies of the social and psychological sciences.

Three basic types of science education research are undertaken empirical, historical and philosophical By far the largest number of studies might be classified as empirical However, many would argue that more historical and philosophical studies are needed if we are to gain a more profound understanding of the nature of the problems that we face

Empirical Studies In empirical studies primary data are collected in a number of ways. Among the data collecting devices often used are : questionnaires, observation schedules, tests and attitude scales Often, these data are used to accept or reject haypotheses

In *controlled studies* conditions are controlled in order to try to discover the influence of one or more variables. In a classic design, two or more groups are equated with regard to all pertinent factors and then the experimental group is given the experimental factor. For example, in one study the effect of open-ended laboratory investigations in science was studied. All factors believed pertinent to science achievement such as the nature of the teacher, length of time devoted to science study and amount of books and other resources available were controlled for two groups. The

sampling procedures are used to define a sample that will give an accurate picture of the total population.

Classroom interaction studies are studies of the interactions, usually verbal, that take place between teachers and students. Sophisticated observation schedules are used. Tape recorders can be used to record all varbal interactions. Various approaches have been developed for the analysis of the interactions.

In *concept development studies* an attempt is made to find out how children develop concepts over a period time. Very often, the data are collected in the form of anecdotal records. An analysis of these anecdotal records often give clue as to the nature of concept development.

Historical studies It has been said that, 'Those who do not study history are doomed to repeat it". Historical studies in science education are designed to help us learn from experience so that we can continue to improve our efforts

Among the difficulties involved in historical research are those of judging the reliability of sources. To the greatest extent possible we should try to get our information from primary sources such as those individuals who were actually involved in an educational endeavour or saw an even happen. Even then the historian desires at least two corroborating witnesses before he can feel very certain about his information. Often, however, we have depend upon secondary sources Then, we must cross-check in as many ways as possible the reliability of our information and state the degree to which we can be certain about key information.

Example of historical studies in science education are "The history of Curriculum Development Efforts in Science

Education over a Period of Time", or "History of Development in Electricity and Magnetism and how these were reflected in Secondary School Physics Books".

Philosophical studies Many philosophical studies are analytical in nature. For example, certain positions in the philosophy of science or the philosophy of education are analyzed for their implications for the teaching of science. One such study was entitled "The Philosophy of Pragmatism and Science Teaching," or, certain practices in science education may be analyzed for their philosophical foundation. Various approaches to laboratory teaching for example, have been analyzed for their philosophical roots. Among the most important philosophical studies are those that analyze various proposals for consistency and their implication for practice. For example, proposals for problem solving as an approach to teaching have been analyzed for their implications for teaching practice.

Problem definition Of special importance in education research is problem definition. There is little point in doing research just to do research. Instead it is much more useful to study problems that have some significance. Research studies may have theoretical significances, that is, the study of a problem may help fill gaps in a theoretical structure. Or, research studies may have practical significance, that is, the results of studies may be useful to science teachers, supervisors, or those who train science teachers. The following are some of the significant problems indentified in our discussion.

hat is the relation between creative scientific work and social conditions—In India productivity was very high in the early stages of her civilisation—went down very low during the middle ages—has come up to only a limited extent at present.

I

2. What is the relation between creative scientific work and education ? Why is original scientific work not of a very high standard in India ? Defect in school education or college education or both-or social or economic conditions.

3. A study of change of attitude towards learning science from class to class or elementary junior and middle school stage – Does interest increase or decrease ? Comparative study of a few schools. Does this depend on teacher, or school conditions ?

4 A study of reasons students have for choosing the science stream at the high school stage.

5. Study of the National Science Talent Search results.
   (a) The schools from which the award winners come-are students from the same schools getting awards frequently ? If so-conditions of these schools-opportunities-teachers etc.
   (b) Background of these students-does home play a important role ?

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Research in Science Education

J. K. Sood

Education in the modern world is taking new turn in both developed and developing countries. It is being influenced by many forces. Two significant forces are the massive financial support to education, and findings of research on learning. Financial support has helped in the development of new curricular programmes, taking them to the classrooms. The research on learning and teaching has given better insight about the learner and techniques of teaching. Thus educators and scientist tried to find the answers of 'what to teach' and 'how to teach.' *Yet these developmental programmes have raised many crucial problems, answers of which are yet to be sought.* If the purpose of all these developmental programmes is to improve schools and instruction then research will be a built-in programme of this whole process. Consequently we shall seek answers of unanswered problems through research. Michael Young in this book **Innovation and Research in Education, (1965)** has said that, 'Without research, innovation will remain subject to fashion, liable to be swept away by the next enthusiast who can present his proposal with a show of charismatic brilliance.' 'He further emphasizes that without research, an innovator, will never be able to demonstrate with any real cozency whether his faith is justified, for whom and in what way.' It is no exaggeration to say that *research is fundamental to educational developmental programmes. Research based developmental programmes should be initiated and encouraged*

so as to get maximum benefit and minimum wastage. I: this post Sputnik era it will be unwise to rely upon trial and-error approach

Developmental Programmes and Research in Advanced Natior

At present new innovations in science education ar gaining currency In advanced countries such innovatior have assumed the role of concerted efforts to provide qualitativ programmes in science. These curricular reforms initiate many new developmental programmes. Most of these scienc curricular projects were developed first in U S A., them U. K. later on many countries of Asia adapted and adopte this material. These innovations include curriculu modernization, improvements in educational researc methodology, more use of knowledge from the field behavioural sciences, and the continuous upgrading teachers through in-service programmes It is difficu to deny the benefits of these monumental efforts, but th question "What is the impact of these efforts on tot education of that nation ?", needs an answer. Pella h very aptly mentioned many problems of similar natu in science education. A few of these problems are (a) What are the fundamental assumptions in scien education ? (b) What should be the programme for teach education in Science ? (c) What should be taught and what grade level ? (d) What is the relationship of teachi to the level of pupils' maturity ? (Pella, 1965).

Similarly Williamson has grouped these problems follows :

(a) Issues related to the purposes of Scien Education.

(b) Issues related to the methods of instructions.

(c) Issues related to the selection and organizati of content.

(d) Issues related to teacher education, (Williamson 1966).

Richardson and Howe have observed that our knowledge of professional education is partial both in its theoratical and applied research. For example, more definite knowledge is needed in learning theory and concerning the desirable and effective behaviour of the science teacher in the teaching-learning situation (Richardson and Howe, 1966).

Such questions are still awaiting accurate answers in the advanced nations, where research is the main criterion to find the answers of problems This breaks the complacency on the part of educators that the development of the "new curricular projects" has solved the problem of science teaching. As it appears to many that these vital issues could not be solved because research in science education did not keep pace with developmental programmes.

Research will help us in identifying the deficiencies in the existing situation. To minimize these short comings and to set a new pace, research and developmental programmes should go hand in hand. Efforts of this nature shall be instrumental in bringing a desired change, which needs acceptance from the people working in that field. Acceptance of a desirable relation between research and developmental programme is of basic significance for all. In this direction many researchers have developed some models. At present Guba-Clark model of change is very popular. 'It place research and development in linear arrangement. It begins on the left with research, carries through two stages of development (invention and design), two stages of diffusion (dissemination and diffusion), and three stages of adoption (trial, installation, and institut'ona-

lization).' Gideonse has developed an out put model. 'This shows that the output of research, development, and operating educational institutions are quite different, that performers of each of the three types of functions have important contributions to make in identifying proposed initiatives in their own sphere as well as all the others (Gidenose, 1968).

Thus knowledge generated by research will strengthen the developmental programmes and in continuity it will upgrade the classroom teaching in different schools, which in due course of time will be a part of the school system.

Meaning of Research and Needed Areas of Research in Science Ecucation

The problem of research and development in science education is not so simple as it appears to be. Identification of vital research areas, development of reliable instruments, involvement of right type of people in research, and retrieval of educational research and other such issues are all closely connected with developmental programmes. Science education is a well recognized discipline and its problems should be solved through research. How we define research, what are the needed areas of research in science education, and how we can establish relationship beetween research and development, are a few important questions, which need further discussion.

According to Webster's New World Dictionary 'research is defined as careful, systematic, patient study and investegation in some field of knowledge, undertaken to establish facts or principles' (Webster's Dictionary, 1968). Tyler writes that the most acceptable definition of research is systematic study in which major generalizations and the bases on which they are made are publicly reported in such

a way as to permit independent verification. The object of research is generalization, that is, the discovery of or the formulation of something which has wider applicability than a description of the particular case or cases which were the subjects of study (Tyler, 1966). Coming to research in science education, Atkin has emphasized that research in science education is a branch of educational research, rather than research in the so-called natural sciences, or research in history, or research in agriculture, or research in some other discipline or profession (Atkin, 1966).

It is certainly this discipline which needs all stimulation to organize research and see its efficacy in classroom situations. Many dedicated researches worked in science education have established a few traditions for the improvement of science teaching.

Many analyzed research reports in U. S. A. (8-18) have helped much in locating the direction in which research in science education is being attempted. They have paved a way to channelize it in right direction as far as possible. In the earlier part of this paper some issues connected with developmental programmes have been discussed. These issues can serve as a base for further research in science education. Watson and Colley have mentioned a few significant areas for research in science education: (a) The learning process: How children learn and the conditions of learning. (b) The learner: How to teach different types of children. (c) The teacher: What type of teaching style is expected from a science teacher, what is the effect of teacher's personality on children etc. (NSSE, 1960.)

Tyler further mentions the areas of research in science education as follows: (a) the objectives of science education What to teach ? (b) the teaching learning process, (c) the

organization of learning experiences, (d) the outcomes of science education, what is actually learned ? (e) the students' development, (f) the development of teachers, (g) the teaching learning process of teacher education, (h) the outcomes of teacher education, (i) the organization of teachers' learning experiences, and (j) the processes of change in science education (Tyler, 1966).

These are very significant areas and need immediate attention of researchers.

Strategies for Developing Nations

In this context research in science education in Asia is not very encouraging. Most of the research studies fall into three main categories.

(a) Survey work, which presents an idea about the existing status and helps in determining the nature of prevailing conditions, practices, and attitudes.

(b) Development of new curricular materials.

(c) Development of some instruments.

A few examples of research attempted in developing nations will present a better view as reported in UNESCO bulletin (UNESCO Bulletin, 1969).

1. The Improvement of Science Teaching in our Elementary schools. Shin shiu, 1967, China.
2. A Study of Scientific Ability. S. Muthulingam. 1968, Ceylon.
3. An Investigation into the Supervisory Techniques in Science Teaching in Delhi schools. Central Institute of Education, Delhi, India.
4. Experimental Projects for Teaching Science and Mathe-

matics at the Middle Level. National Institute of Education, New Delhi, India.

5. A Survey of the Science Education Problems. Korea.
6. Study on the formation process of children's basic cencepts on science, 1968, Japan.

With particular reference to India research in science education is in its embryonic stage. Most of the research is conducted by the Science Department of N. I. E. A few examples are :

1. The determination of the place of science as curricula of schools and preparation of the syllabi for various levels of education.
2. Preparation of piolet text books and teaching aids for the pupils and teachers.
3. Organizing of out of class activity of pupils in science by starting science clubs and science exhibitions of the things made by pupils (UNESCO Report, 1964).

A few other examples

1. Mathematics and Science Education in Indian Schools. V. N. Wanchoo, 1965.
2. Survey of Physics Teaching in Rajasthan N. Vaidya, and Suresh Chaturvedi, 1968.
3. A Study of Lesson Plans in Science. N. Vaidya and J. K. Sood, 1968.

No doubt such studies help in improving the science teaching, yet much more significant remains to be done. Such studies are incidental in nature. Many times, research studies were attempted to fulfil the University requirements for Master's Degree in Education.

Summary and Recommendations

Here, I tried to show that what type of research is being attempted in science education. Further, it is neccessary that some definite relationship should be established between developmental programmes and research. A simple relationship of this nature has been presented by Clark. According to him there are four identifiable phases or processes related to and necessary for change in education.

1. Research
2. Development
3. Diffusion
4. Adoption (Clark, 1966)

In this schema it is assumed that research will be basis for invention, developmental phase will help in formulating new solutions to the operating problems, which shall be for institutional use. During diffusion phase, there will be widespread awareness about the invention and many of the users shall try to examine it. In last phase; adoption, users shall try to use it in their school system which shall be a part of thit institution in due course time.

We should not feel satisfied only by popularizing innovations It shall be wise to provide research support to these innovations Other significant areas of research in science education are .

1. Concept formation at the elementary stage
2. Organizing and sequencing of learning experiences fro
   K through 10th grade.
3. Development of attitudes toward science and scientist
   It is of great significance for developing nations whe
   'spirit of science' and 'mode of inquiry', needs mo
   application in daily living.

4. Developing problem solving abilities and rational thinking through science teaching.
5. Development of proper teaching styles among science teachers.
6. Preparation of new material for different social and economic conditions.

Our current resources in educational research are unequal to the demand placed upon them by the felt necessity of much research. More funds should be alloted to improve research.

Research in science education should be 'highly operational, closely tied to teachers and schools.' More application of research findings to educational problems is needed.

There are, at the moment, not enough experts (*in developing countries*) in the new approaches and instrucational technology in science education. Researchers are poorly trained and brute fact of the truth is that most of the science educators are ignorant about the areas of research.

Centres, devoted to research, development, innovation and experimentation must be created, where teachers can go for periodic upgrading in knowledge.

It shall be highly useful to start science education courses at Master's level, at some places.

A few Journals of research in science education should be started, which will help in reporting and disseminating information to the profession.

Let us not forget that no body can teach people to do research. It is environment which helps in developing

interest among the researchers, and step by step, pioneer researchers shall be available. There is a need of careful and planned approach to fill the gap. Research in science education should be an essential part of educational research if we want an answer of outdated, ineffective science teaching in developing nations. The findings of research should be used in classrooms. Howe has very aptly said that Science education should be concerned not only with research, but engineering of research so that it can be translated into active use in the classroom (Howe, 1966).

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II

TRENDS IN SCIENCE EDUCATION

The strategies of learning must be related to the conditions that will lead to an understanding of the conceptual structures of science and of the modes of scientific inquiry.

* * *

A newly conceived curriculum prescribes a style of teaching consistent with the goals of instruction and with the nature of the discipline.

Paul DeHart Hurd
Theory into Action.....in science curriculum development, NSTA
Washington, D. C. 1964

Science Education in the United States

J K. Sood

Last two decades have witnessed an unprecedented development in science teaching improvement throughout the world. The United States has her own history behind this international feature. Beginning from simple observations of things to nature study, learning of science became fundamental, basic and parallel to languages at the elementary stage. Preparation of scientifically literate citizen and sharperning of creative abilities are the main aims of science teaching. 'Science for information' and 'practical purposes,' is an old theme. Wary curriculum is being replaced by dynamic, all inclusive curriculum. 'Explosion of scientific knowedge' and 'fear of falling in obsolescence,' there by, demanded new approaches to curriculum organization. Major conceptual schemes as a basis of curriculum organization is one of the many answers. A tired and overburdened teacher is helped by teaching-machines, computor assisted learning, plenty and varied audiovisual aids, self learning instructional material and many other such innovations. Of course this is an application of instructional technology in the schools. Piaget presented some ideas about the developmental stages of children which were useful in planning for learning and teaching (Piaget, 1963). Gagne suggested ideas about sequencing of learning activities in hierarchical order (Gagne, 1964). The 'structure of discipline,' one of the effective ways of organizing curriculum is emphasized by Bruner (Bruner, 1960). Evaluation is a built-in programme of science curriculum. Learning outcomes ar

described 'behaviourally'. This is highlighted by Mager (1962), Atkin (1968) and Bloom (1968). Problem solving approach, discovery approach, learning by doing, invitations to inquiry are the popular innovations of post-Sputnik era.

Skinner, Bruner, Ausubel, Gagne all top psychologists helped in preparing science curriculum in collaboration with Zaccharius, Schwab, Karplus, Gleann Seabarg, and Garett. It is difficult to ignore the contributions of Hurd, Jacobson, Renner and other science educators in this joint venture of preparing new curriculor material. All these achievements have rich and long past.

And the history runs like this. In 1872, Harvard College announced, the required practical work in physics and other sciences for college enterance which was accepted by most of the colleges. Again in 1887 Harvard issued a list of 46 experiments to be completed by high school students in physics. These were pace setting initiatives, which were followed by most of the colleges. Later on emphasis was laid on experimenal work and provision was made for double laboratory period. Teaching was for development of thinking rather then memorizing. Where, when and under wha circumstances various changes in school science subjects appeared in American schools have been reviewed by many authors (7-14).

In the early beginning of this century many significant changes occured There was a rapid increase in high school enrolement. Science subjects become terminal at the high school stage. It also served as exploratory subjects for those who will continue their studies. General science substituted Physical Geography as the first year subject for the four year science sequence. Timely publication of many reports on science teaching, helped much in the improvement of teaching. A report on the reorganiza- of science in the secondary schools was published by the

the sub committee of the Commission on the Reorganization of Secondary Education of the National Education Association (Otis, 1920). The report indicated many weak points

A committee of the American Association for the Advancement of Science in 1927 issued a report entitled *On the Place of Science in Education*. This report emphaized the importance of scientific thinking as an objective of science teaching (Woodburn, Obourn, 1965). In 1932 the Thirty first Yearbook of the National Society for the Study of Education was published. Its impact on Science teaching was tremendous. Main influence was on tewelve year science sequence, beginning from the elementary school and teaching was based on main generalizations.

In 1932, a bulletin entitled *Instruction in Science* was published. In 1938 the commission on Secondary School curriculum of the Progressive Education Association issued a report entitled *Science in General Education* Another famous publication was Forty - sixth Yearbook of National Society for the Study of Education, in 1947 The main recommendations were as follows

1. Science instruction should begin early in the experience of the child.
2. All education in science at the elementary and Secondary Levels should be general.
3. The development of competence in use of scientific method of problem solving and the inculcation of scientific attitudes transcend in importance other objectives in science instruction (N.S.S.E. 1947).

Since World War II many new ideas were included in school science-subjects. In the early fifties new technological discoveries and social changes highlighted the glaring

inadequacies in school education. The result was an extensive reduction in the curriculum—lag between the discovery of new knowledge and its inclusion in the classroom teaching. Recently many other factors have demanded sweeping changes. During 1953-54 Science Manpower Project of Teacher's College, Columbia University, New York, started a few projects for the improvement of science teaching. In 1956 efforts were a foot to improve physics teaching in secondary schools of the United States. The launching of Sputnik I (Oct 4, 1957) accelerated the pace of new science curriculum development. Further, a two-year study on Soviet Education, publicly released on Nov 10, 1957, cautioned the Americans about their school education in general and science education in particular. This 226-page booklet stated that students in the USSR's 10-year primary-secondary education programme devote much more time to such subjects as physics, biology, chemistry, mathematics, and foreign languages. The Russian High School Student attends classes for six days a week and receives from 1,224 to 1,271 hours of instruction a year, as compared to 895 for the American Students (Lavina, 1958). In such circumstances, science education became a national concern for Americans. All different aspects beginning from the philosophy of science to classroom teaching were thoroughly re-examined. New curriculum projects were started, new theories were evolved and every effort was made to revitalize it. This time the changes were very drastic as well as fundamental.

The development of these curriculum projects can be divided into three stages. In the first round "alphabet" courses were prepared, starting in 1956 from PSSC (Physical Science Study Committee), then SMSG (School Mathematics Study Group), CBA (Chemical Bond Approach), BSCS (Biological Science Curriculum Study), and CHEM Study (Chemical Education Material Study).

At the second stage efforts were made to improve the elementary school science The impact of "alphabet" courses demanded a change at the elementary stage. After all, secondary education can't exist in isolation. This was the beginning of many projects such as : ESS (Elementary Science Study), Science—A Process Approach, prepared by the American Association for the Advancement of Science, SCIS (Science Curriculum Improvement Study), COPES (Conceptually Oriented Programme for Elementary Science) and many others. Attempts were also made for a few High School Science Projects, such as ESCP (Earth Science Curriculum Project), HPP (Harvard Project Physics), IPS (Introductory Physical Science) etc.

This evolutionary process is going on but certain definite changes are visible. Science instruction starts with 4-5 years old children in the kindergarten and continue through twelfth grade. There are specially trained teachers or instructors to teach science in more or less all grades. Most of the schools use films, demonstration and other teaching aids (Jacobson, 68). School structures in the United States are 6-3-3 (elementary-junior-high-senior high school), 8-4 (elementary-secondary) and to a lesser extent, 6-2-4, 7-2-3 and other local variations. At the elementary stage different disciplines are integrated and at ten, eleven, and twelve levels, students will study only one science.

These nationally admired and internationally acknowledged science course content improvement projects provided new directions. It is not possible to list all these projects but a brief summary of some projects is presented (24-37).

Secondary School Curricular Projects

History of the Project	Objectives
P. S. S. C. Physical Science Study Committee : initiated in 1956 at Massachusetts Institute of Technology. Materials released for general use in 1960, after testing.	Students shall learn basic principles of physics. To present comprehensive view of physics, as seen by today's physicists. To present physics as a system of inquiry. To develcp an understanding that physics is a unified and ever changing subject.
SMSG School Mathematics Study Group : initiated in March, 1958 at Yale University.	To develop understanding of skills in mathematics. To encourage exploration of the hypotheses underlying mathematics education. To foster research in the teaching of school mathematics.
BSCS Biological Sciences Curriculum Study : initiated in 1959 at Boulder, Colorado. Principal originator is American Institute of Biological Sciences.	To improve biological education at the high school level To give contemporary knowledge of biology which reflects the structure of biology. The emphasis is on nine major themes.
CBA Chemical Bond Appro-	The emphasis is on ideas, and

Evaluation	Characteristics
Sets of achievement tests are being developed and used.	PSSC Physics project was the first major curricular reform which gave lead to the others. The Committee was of the view that the fresh start was the only sensible strategy for science curriculum. It had some specific plans for the teacher training programmes
Conventional classroom methods of teaching and techniques of evaluation are used	SMSG has prepared sample text-books for grade K-12. Major difference in these text books is that of organization and methods of presenting topics.
BSCS has made substantial progress in developing and using tests that determine the attainment of course objectives.	BSCS is unique in that there are three sets of parallel material, Yellow Version, based on cellular approach, Blue on molecular and Green on ecological. Further, there is special material for backward children which is known as Patterns and Processes of Science. The development of Second Course in biology is another effort.
Evaluation is being made by	This project is no longer

ach Project: initiated in 1959 Summer at Reed College.	the theme of the ideas di cussed in chemical bondin The *purpose of the laborato* work is the exploration ideas, the utilization of expe rimental data.
CHEM Study Chemical Education Material Study: initiated on Jan. 9, 1960 at the University of California.	To diminish the separtion bet ween scientists and teacher in the understanding of scie nce. To develop an under standing on fundamental and *unifying concepts of chemistry.*
ESCP Earth Science Curriculum project: initiated by *the American Geological Institute* in 1963 at Boulder, Colorado.	This is based on interdisciplinary approach to science. *It gives a comprehensive view* of the planet earth and its environment.
HPP Harvard Project Physics: initiated in 1964 at Cambridge, Massachussetts.	*To present physics* in a broad humanistic context. To show connection between physics and man's other intellectual, artistic and social *activities.*

Curricular Projects for Elementary School Science

ESS Elementary Science Study: initiated in 1960 at Cambridge, Massachusetts.	It was started to *provide* meaningful, *experiences to* elementary *school children.* To provide a variety of carefully thought out and tested materials

weekly reports sent by teachers and CBA staff.	engaged in production [illegible] materials.
Trial editions were used for three years on the basis of which course material was improved.	It highlights the differenc[illegible] among observations, assum[illegible]ptions or interpretations [illegible] conducting experiments. [illegible] employs the inducti[illegible] approach.
It developed differential aptitudes tests of science knowledge for judging the effectiveness of the materials.	It is accepted that inves[illegible]gations give better understan[illegible]ing of the content. Hen[illegible] materials are based on e[illegible]perienced centered inquiry.
A series of tests and questionnaire designed to detect the changes, needed in physics teaching.	It reflects flexibility with [illegible]gards to emphasis and teac[illegible]ing strategies. It tried [illegible] present an alternate mater[illegible] for physics students to che[illegible] the declining percentage [illegible] students offering physics [illegible] high school.
There is a control group. Feedback process is in vogue for evaluating booklets and materials from the point of view of teachers.	To upgrade science cont[illegible] as was attempted by PSSC

Science-A Proces Approach developed by AAAS Commission on Science Education : Initiated in 1962 at Washington, D. C.	Material is prepared to develop intellectual skills of children. It emphasizes on processes of science through experimentation. The sequential ordering of Science process skills by increasing complexity defines a hierarchy of skills for each process.
COPES Conceptually Oriented Programme in Elementary Science : initiated in 1965 at New York University by Morris. H. Shamos & J. Darrell Barnard.	To prepare an elementary programme based on major concepts or conceptual schemes. Methods of investigations are not excluded.
SCIS Science Curriculum Improvement study : Initiated in 1962 at the University of California, Berkley by Robert Karplus.	Main purpose of science courses is to develop scientific literacy. Its meaning is two fold; first is to get sufficient knowledge and understanding of the fundamental concepts of both the biological and physical sciences, secondly it should develop a free and inquisitive attitude and rational procedures for decision making.
ESSP Elementary-School Science Project : initiated in 1960 at Urbana, Illinois by J. Myron Atkin and Stanley P. Wyatt, Jr.	To develop and write materials that reflect the structure of astronomy as it is viewed by professional astronomers.

To measure competency developed by each exercise *A science Process Instrument is used.* Control groups are also used, Teacher submits a feedback form and competency measure results for each exercise taught.	It is a major effort to emphasise on processes of science. Exercises from many disciplines are included. Hierachical order is based on the philosophy that higher elements can be attained only after doing some work on the lower ones.
Test of Science concepts is used. Control group, feedback also in use.	Its purpose was to test the feasibility of a conceptual scheme approach to curriculum development in elementary science.
It is based on teacher observaon, behaviour of children and behavioral outcomes.	It is believed that science should be simplified for the elementary stage. Its organization should be different than the usual logical subject matter presentation.
For evaluation purposes objective tests and obsevation scales are used, Pre and post tests are used.	It emphasizes that certain concepts are central to an understanding of astronomy by children in the upper elementary a grades.

Common Elements of New Science Courses

A few common points emerge from these efforts:

1. Public awakening and desire is needed to get better and effective education. Many funding agencies gave massive amount for the development of new curricular materials.
2. Never before university research scientists tried to prepare new materials in collaboration with science teachers and educators. The objective was to make the content up-to-date, its proper organization, and its testing in the classroom.
3. It was acceptable to all that the purposes of science teaching are to prepare scientifically literate individuals and to develop the rational powers of the children. Content mastery, process acquisition were not only the main purposes but attitudinal changes and career guidance was a part of it.
4. Laboratory work was the main theme of all projects. Inclusion of open-ended experiments helps in maintaining the spirit of inquiry. "Invitations to Inquiry" highlighted by Schwab is a break-through in science teaching.
5. Never before educational technology was included so heavily. Development of cheap equipment, preparation of kits, use of computors, programmed material were included in most of the projects. Yet lecture, group discussion and independent study were not excluded.
6. Supplementary material was prepared to substantiate the learning. Use of films, film strips and simulation was a part of the whole programme
7. Most of the projects included some programme for teacher education. To popularize and implement new philosophy in science teaching, the role of the science teacher, and his adequate training was highlighted

8. The materials were subject to rigorous experimental trials. The trial editions helped in judging the efficacy as well as its feasibility.
9. Most of the projects also developed their evaluation instruments for further improvement.
10. A continuing revision of the scientific knowledge helps in eliminating the fear of using obsolete material.
11. The new curricula included 'concepts' 'conceptual schemes' and tried to present 'structure of the discipline.' This will help in avoiding the compartmentalized or topical approach to science curriculum. It is better to understand the nature of science rather than understanding a few assorted topics

Other Programmes for the Improvement of Science Education

After studying all these curricular projects it is easy to generalize that it is a discipline-centered movement, and a number of private and public agencies helped actively in the improvement of science teaching. A number of famous publications highlighted new strategies in science education and became a part of history. Jerome S. Bruner, who is a supportor of 'structure of discipline' in curriculum planning and role of 'intuition' in learing published *Process of Education* in 1960. It is an oft quoted report of 1959 Woods Hole Conference. It emphasises on the role of 'structure' in learning and how it may be made central to teaching. The second theme emphasises on some aspects of readiness for learning. The third theme includes the nature of intuition and the last one is related to the desire to learn and how it may be stimulated. Bruners' bold hypothesis (one of the oft quoted ones), reflects faith in the ability of children, "that any subject can be taught effectively in some intellectully honest from to any child at any stage of development".

Most comprehensive publication on science teaching is the *Fifty-Ninth Yearbook* of the National Society for the Study of Education, Part I, *Rethinking Science Education*. It gives new ideas about outcomes of science education, role of science in American Society, new ideas about curriculum development, needed research in science education etc. Its impact is yet to be seen. NSTA published many documents. *Planning for Excellence in High* School Science (1961) and Theory into Action (1964) are worth mentioning. *Theory into Action*, gave some ideas about the role of conceptual schemes in curriculum framing. The revised edition of 1969 included many constructive suggestions given by many workers. A number of textbooks and teachers' manual developed by different agencies presented up-to-date content and emphasized on new methods of teaching.

Education and the Spirit of Science (1966), a NEA publication demanded new role of science in the American society. It redefined the values of science teaching: longing to know and to understand; questions of all things; search for data and their meaning; demand for verification; respect for logic; consideration of premises; consideration of consequences. Other similar publications helped much in improvement of science teaching.

Role of Agencies and Professional Journals

Many agencies private and public both helped in funding and providing expertize to the cause of science education. National Science Foundation supported financially most of the curricular projects. It also helped financially the Summer Science Training Programmes, Science Teaching Centers etc.

Professional agencies such as National Science Teachers Association, Central Association of Science and Mathematics

Teachers, American Association for the Advancement of Science, American Institute for Biological Sciences etc. contributed much for all that is going on in American Schools. Professional Journals such as: *The Science Teacher, Science and Children, Science Education, School Science and Mathematics, Journal of Research in Science Teaching. The American Biology Teacher, Science,* etc tried to collect and disseminate knowledge to the profession.

Establishment of (ERIC) the Educational Research Information Centre at Ohio State University, Columbus, International Clearing House on Science and Mathematics Curricular Developments at the University of Maryland, Mid Contimental Research Laboratories etc., promoted research in Science education.

The Ford Foundation, Rockfeller Foundation, Bell Laboratories and many other agencies helped in this venture of science teaching improvement.

Use of Instructional Aids

Use of instructional materials became an integral part of all science curricular courses in the learning process. Just to collect a few teaching aids in the school is an obsolete idea. Particularly at the elementary stage most of the material is a necessity for completion of the course Many agencies have developed new instructional materials and laboratory equipment.

Influences of programmed learning, teaching machines, computor assisted learning, education through television, films, filmloops cannot be overlooked. These aids helped the teacher in teaching and saved his time for creative work. Skinner and others emphasized on the use of programmed materials and teaching through machines. Teaching machines

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help much in popularizing the philosophy of self learning and computors work as an *automatizing devices.* Films and television programmes help in explaining the underlying structure of many complicated things.

Thus all these instructional aids help in expanding experience, clarifying complicated concepts and give some personal significance provided all these viewed in the context of total programme of education

Summary

The purpose of this article is to give, in brief, an idea about the development of science teaching in its historical perspective. The improvement programme is a continuous process which demands rigorous evaluation of the complete process and faith in change for the betterment. No doubt, in this post-Sputmik period many sweeping changes were undertaken by joint efforts of many dedicated workers. The improvement programme depends on many significant factors, namely; how we look at science education, public interest in the education of children, availability of funds, priority to research and experimentation and sincerity of the workers in the field of education. The change cannot be effective only by initiating new programmes but it depends more on the new practices which these programmes establish.

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Nuffield Foundation Science Teaching Project

A C Chaudhury

Introduction

The Nuffield Foundation Science Teaching Project arose as a result of wide spread interest in curriculum reform which began to gather momentum in Britain during the late 1950's. This interest was originally fostered by bodies such as Association for Science Education and pioneer work by various individual teachers.

The project at the ordinary level of the General Certificate of Education (GCE) consists of three separate enterpises in Physics, Chemistry and Biology. Though these are three different branches of science–the projects have maintained close link with one another being grouped together administratively under a single head–the Nuffield Foundation. As these three sciences are often studied concurrently at O–level, it has necessitated a careful synchronization of certain sections of the three Nuffield Courses. For instance, in developing the Biology course it was important to make sure that assumptions made in other fields were justified and that a topic such as "oxidation" had been adequately covered on the chemistry side by the time it was needed in the study of say "respiration".

Choice of an Age Group

The mandate of the Nuffield Science Teaching Project was to consider the requirements of those children within

the age group 15-16 years who would normally take G.C.E at ordinary level.

Aims

(1) Its primary purpose has been to provide a sound introduction to modern science for those chidren who will leave school at the age of 16 and have no formal science teaching.

(2) As a secondary requirement, it has aimed to provide a suitable background for more advanced/specialist work. The aims of the course can be summed up as follows :

(a) to foster and encourage an attitude of curiosity and enquiry.

(b) to develop a contemporary outlook on the subject.

(c) to teach the art of planning scientific investigation, the formulation of question and design of experiments.

(d) to develop a critical approach to evidence.

The Nuffiled Approach

The present syllabi are largely concerned with cataloguing of specific materials and stating concepts. Memory plays the dominant role. The Nuffield approach emphasizes rather manipulative and intellectual skills. The Nuffield course cannot be memorized from a book-experiments must be done and understood by the pupils themselves. True understanding does not come from the formal learning of definitions or the working of examples by substitution numerical values in the formulas. It is more important to know the meaning of a formula and where it comes from, than to learn that formula by heart. The attempt to develop

a more contemporary experimental and enquiring attitude in teaching and learning has demanded not only consideration of what is taught (although this is also important) but much more of how the teaching should be conducted. Through the medium of "Texts" and "Guides" the aim has been to show how a more experimental approach in the laboratory (obtaining first hand evidence) and a more critical approach to second hand evidence (derived from the literature) can lead to a more lively and truely scientific outlook among pupils.

The Courses

The courses on these three sciences that has been developed now is the result of a co-operative enterprise, not just the activity of a few individuals. Close consultations have always been maintained at every level of the educational edifice, particularly with schools, training colleges, technical colleges and University Departments. In addition, the materials and examinations have been subjected to extensive trials under classroom condition. In the light of all this flow of information, the texts, guides and films have been extensively revised prior to their publication.

The course is spread over five years. The first two years are introductory while the remaining three are the intermediate phase.

The Nuffield course have sought not so much to introduce new factual material, although this has been done to some extent as to re-orient the approach to that, which is already taught. This has demanded new teaching techniques and new kinds of resource material. Text for students which is geared to the Teacher's Guide and

laboratory manuals have been prepared for each year of this course.

For example the Biology Course falls into 2 parts.

The first two years (introduction) cover a wide range of subjects from species and bacteria to shape and size. The remaining 3 years in which the treatment is far more detailed and a body of emperical knowledge is built up.

A text and a teaching Guide have been produced for each of 5 years of the Course and these are mutually dependent. The *Pupils Text* combines vital information with instructions on how to do the requisite experiments. It does not give the answers but poses the questions that used to be answered in order to understand the subject. The Teachers' Guide gives commentary on methods of teaching and the setting up of experiments. It also gives alternative and additional experiments

Again for the Physics course the Nuffield people have produced *for the teachers* a Teachers' Guide and a Guide to experiments (containing full details and diagrams for each experiment) for each year of the course For *the pupil* a questions box that is geared to the Teachers' Guide and provides farther and fuller problems for the pupil to work out in class or at home The course is constructed in such a way that it can start at any point except years I & III.

The pattern of course constructed for each year has been described in the small booklets.

Background Reading

Students must be provided with adequate opportunities for reading outside the confines of the course. Suitable

references are often difficult to find and even if availa
their use by large number of students can place intoler
strain on school library facilities. To eliminate this difficu
at the end of each chapter in students' text in biology a
pages of background reading have been provided.
material is intended for out of school use and covers a g
diversity of topics each related to the chapter preceding it.

Film Loops & Films

Visual aids play an imporatant part in the Nuf
course. 16 mm. sound films have been prepared for Ch
stry and Biology. A series of 8 mm. film loops
been prepared for Biology and Chemistry courses acc
anied by teaching books. Most of therse film
are in technicolour and take not more than three mi
each. The projector is simple to operate and no bla
is required.

Background Books

In physics there is one Background Book designe
use in year III.

Apparatus

Should extend knowledge rather than simply t
Students can look upon them as a helpful part of the c
rather than a hurdle at the end of it.

Throughout the course emphasis has been la
personal investigation by the pupils. So it is to be ex
that capital and recurrent expenditure will be som
higher than for *conventional* course.

In Biology the cost of the apparatus for the
for a class of 32 can be broken down under 3 headings

(a) Basic apparatus: This consists of major ite

equipment which are required throughout the course. Microscopes by far the most expensive item which would cost normally between £ 50 — £ 80 — per piece. But a Junior version of the microscope suitable for 0 — level Nuffield course has been prepared now at a cost ranging from £ 15 – £ 35 — per piece. Other typical items under this heading include a refrigerator, incubator, balance, centrifuge and thermostat water bath.

(b) Capital Equipment for each year. In each of the five years certain special equipment is required for the work of that year. For instance an apparatus is needed in year *I for the study of* earthworms.

(c) Expendable materials for each year such as reagents, cultures of plants, animals etc.

In Physics

Some additional items of apparatus are necessary. They are described in details in "The Guide to Apparatus."

Examinations

It has been realised that the nature of examinations would ultimately determine the success or failure of the course. Therefore, the nature of examination has been changed. The traditional type of paper involving a few long questions has been replaced by one containing numerous short ones. This has two advantages :

1 It gives a wider coverage of the syllabus.

2 It gives a greater reliability in marking.

The questions used in the Nuffield course can be divided into six categories :

(a) Simple recall-based on factual material memorise by the candidate.

(b) Association recall-questions demanding the associa tion of one piece of recall information wit another.

(c) Experimental recall-concerned specially with th kinds of experimentation which have bee carried out by the candidate.

(d) Experimental Design—involving the design experiments to test particular hypothesis.

(e) Deductive-the reading of graphs and tables, formu ation of hypothesis from data provided and th selection of the most likely of a number different hypothesis

(f) Continuous Prose—a short essay of about 25 words intended to test a candidate's ability t express himself in his own words.

This arrangement is a marked contrast to existin mination papers at O-level where the questions are almo ariably of the simple recall type.

It will be useful to recapitulate the aims of Nuffiel ndation Science Teaching Project as stated in t gress Report of 1963

The central objective is "Science for All" – not merel the future specialist but for the future citizen in th er half of the twentieth century. The programme ha n designed initially to concentrate on four broad sections sics for 11–16 year olds, chemistry for 11–16 year old logy for 11–16 year olds; and science for 8–13 year ol primary schools and non-selective secondary schools.

The aim in the first three sections is to provide an ire ited range of tested teaching resources in physics, chem

try and biology, designed by teachers for teachers. The material will be designed to be equally suitable for future science specialists and for those who later specialise in other subjects or who leave school at the age of 16. It will be intended primarily for use in the first four or five years in grammer schools and the upper streams of secondary modern schools, and will offer to all who might normally study for the G C.E. 'O' Level (or Scottish 'O' Grade) examination some insight into scientific thought and method. The appropriateness of the material for those pupils likely to sit for the new Certificate of Secondary Education will, however, also be carefully investigated (1).

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Primary and Secondary Education in USSR with Special Reference to Science Teaching

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Raghavendra Rao

The Education system in USSR is uniform all over the Country and meets the requirements of citizens of all ages. It provides opportunities for everyone to acquire knowledge and improve their qualifications at any stage Adult illiteracy has been wiped out in a miraculous way. Education up to eight years of schooling is compulsory and encouragement is given so that all complete their ten years of school education. All the Republics in USSR have a vide net work of schools and every attempt is made to spread education. Over 80 million have primary education. An average school has about 1000 to 1200 students with 40 to 50 teachers. Generally city Schools run in two shifts, first shift from 8.00 A.M. to 2.00 P.M and second 2 30 P.M. to 7.00 P.M In general Schools can be divided into two categories :

(a) Primary and Secondary Schools of general nature and
(b) Specialised Secondary Schools.

(a) Primary and Secondary Schools of General nature

Ten years of Schooling can be divided into two divisions : (i) Primary and (ii) Secondary.

Primary Schools

Primary School is a part of the Secondary and there is

no separate primary school. At present the Primary schooling is of four years. In class one, the boys and girls are admitted at the age of seven. Only one teacher teaches all the subjects and in most of the cases the teacher is a lady. The following subjects are taught :

First Grade : Reading (Elementaey), making of simple and complex words, writing (elementary) and writing of alphabets, counting, simple addition, substraction, multiplication and division (within the limit of one thousand), *construction and solving of simple problems.*

Drawing : Nature (imagination-understanding of colours), physical culture, playing games and other activities such as *music and sewing.*

The class *work is for six days in a week* and each day it is of four hours duration.

There are facilities in all Primary Schools for learning dancing and foreign language and for this special fees has to be paid to the school by the parents. The teacher incharge of these classes gets extra remuneration.

Second Grade : All the subjects mentioned above *plus* grammer (Noun, Pronoun and Verb).

Foreign language and dancing are taught if extra payment is *made during the second grade.*

Working hours—Five hours for two days and four hours for four days.

Third Grade : Fractions , *measurements in metric system,* elementary geometry.

Grammer : cases, forms of verbs, tences, building of *sentences, direction and composition.* (Together with all the subjects of second grade). Facilities for learning foreign

language and music on extra payment are continued at the third grade also.

Working hours — Three days of five hours each day and the other three days of four hours.

Fourth Grade : In this class, the orientation is towards preparing them for secondary school. All subjects of the fifth grade are taught in an elementary manner in this class.

The subjects are · Geography, history, biology, arithmetic, Russain language, music physical culture and a few elementary ideas of algebra. Advance drawing related to draughting and designing starts

Note :—The Primary School academic hour is of thirty minutes duration.

Co-curricular activities [illegible]

In the first grade the children of a class are divided into four or five groups under an orgnization 'OCTYABRYATA'. The main aim of this is to prepare the children to become good 'Pioneers' later. These groups will be incharge of keeping the class room clean, helping the teachers by bringing chalk, dusters etc. and to check whether all the children bring their books regularly to the class or not etc. The children cut interesting pictures from various newspapers and display them on the bulletin board They also write small poems and make cartoons for dispay. Both within the class-rooms and in the corridoors bulletin boards are fixed to the walls in large numbers for such display. Class rooms are always kept clean and colourful. Every Saturday children celebrate the birthday of those who are born in that week. They also celebrate the birthdays of great leaders like Lenin and eminent poets and writers. National Festivals

like 7th Nov., First May and First Jan. are celebrated on a grand scale.

Besides these, they also do useful work in garden in cloak room, in cleaning the school corridor and help in the *dinning room* (not cleaning the utensils as such type of work is not allowed by doctors).

In grade second and third they do the same type of work. In third grade they become Pioneers.

Secondary Education

Secondary education has been divided into two stages.

(a) *Vth Grade to VIIIth Grade and,*

(b) IXth grade to Xth grade.

Subjects taught

Fifth Grade : Russian literature and *language,* foreign language (English German, French, Spanish, Hindi and etc.), algebra, arithmetics, botany, geography, history, physical culture, music, drawing, manual training (*Carpentry and metal work for boys, domestic science* and tailoring for girls.)

Sixth Grade : All subjects for class five plus zoology, physics, world geography.

Seventh Grade : All subjects of grade sixth plus geometry, chemistry and geography of USSR.

Eighth Grade : All the subjects of grade seven *plus* anatomy, physiology (human), boys do only metal work and the girls start nurses training.

They are examined by the board at this stage. Some of the students after eight years of schooling go for Technical school *or some other courses* and the *rest continue the* Higher Secondary Education.

Ninth Grade : All the subjects of Grade Eight except music and biology plus economic geography and trigonometry. Manual training is of specific nature such as radio mechanic, drivers work and automobile technique etc.

Tenth Grade · All subjects of nineth grade plus astronomy.

At the end of the tenth grade students have to pass state examination and they are given two certificates,

(a) certifying his knowledge in the subject and

(b) certifying his technical skill.

After ten years of schooling they can either go for University education, medical or any other higher institutes of learning.

Co-curricular Activity There are different clubs like painting, archeological, sports and societies like Science, historical etc.

Working hours for the garde Vth to Xth Each period is of forty five minutes duration. Work is carried out for five periods on some days and for six periods on other days One day is entirely devoted for special training in workshop. There are two terms in each year. The first term beings from 1st September and ends on the 31st December. The Second term is from 15th January to 31st May.

The State examinations are conducted in the month of June.

Teachers working load, salary and qualification:

In the Primary Schools, a single teacher teaches all the subjects to a particular class and the work load of the teacher will not exceed 24 periods per week. If the primary teacher has graduated from a pedagogical school his starting salary would be 60 Rubles per month; if he has graduated

from a pedagogical institute, the starting salary is 80 Rubles per month. The Primary teachers from Pedagogical Schools will have finished 8 years of schooling and those from the pedagogical institutes will have finished ten years of schooling.

Graduates who have undergone training in a pedagogical Institutes for four or five years after ten years of schooling are entitled to become teachers of secondary schools. The working load is 18 periods per week and if they work over-time extra remuneration is paid to them. The starting salary of a Secondary School teacher is about 100 Rubles per month

Secondary School—*In order to meet the individual* differences and requirements of talented children and slow learners, to spot out the aptitudes and abilities and offer training accordingly and also to train pupils for professions of National Economy, various types of special schools have *been established. They can be classified into the following* categories.

(i) Special Polytechnical Schools.
(ii) *Special Schools for gifted children*
(iii) Special Schools for Physically weak children.
(iv) Special Schools for mentally retarded children.
(v) Boarding Schools.
(vi) Special Language Schools.
(vii) Collective farm Schools.

(i) Polytechnical School

In general all schools in USSR have polytechnical bias; but in certain schools greater facilities are provided for polytechnical training. A number of measures have been taken with the help of experts on the basis of production and agriculture to make this kind of training very effective

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as to have a bearing on National Economy. The starting of such school is the result of a joint venture of school employees, patrons, Soviet industry and Soviet society. These schools have model study halls and workshops which are very well equipped. Managers of many undertakings and establishments as well as public are assisting in the task of building a polytechnical base in these Schools. They have provided automobile engines, lathes, different agricultural machines and tools, cinematography equipments, textile machinery etc. The children in these Schools have ample opportunities to get training in factories or textile mills or in collective farms. These industrial undertakings and farms maintain close and constant contact with the school authorities and children. Even the methods of teaching physics, chemistry, mathematics, biology, geography etc in these schools are oriented polytechnically. There is close co-ordination between the theory taught and the practical work done by the pupils in industrial undertakings. Technical circles, factories, workshop repair shops of tractor stations and out of school enterprises provide all requisite facilities. Frequent excursions and field trips to factories and farms are encouraged. Most of such schools have experimental plots near by. Love and interest towards agricultural work are being cultivated among the students by inclucating concrete practical habits in their spheres.

(ii) Special Schools for gifted Children

There are five Schools in USSR specially meant for gifted childern in Science. These schools are located at Moscow, Leningrad, Kiev, Novosibrisk and Tbilisi. These Schools are for different regions of USSR. In an ordinary School the gifted child may find the routine curriculum disinteresting and may lose interest in the learning aspect. In order to make the curriculum quite challenging to the

interests and abilities of gifted children special schools with special curriculum of high standard of certain science subjects like physics, mathematics, chemistry and biology have been started. In other subjects the curriculum of the school is the same as in ordinary schools. The combination of subjects speciality offered at these schools are as follows :

(i) Physics and Mathematics : Moscow, Leningrad, Kiev and Tbilisi.

(ii) Biology—Novosibirsk

(iii) Chemistry—Novosibirsk.

Admission procedure : Only best students can aspire for admission in these special schools. A preliminary examination is held in the cities and towns where the student is studying. If the performance come to expected standard then the students is asked to take another entrance examination in the special school where he is seeking admission. The best out of these are selected for admission. The examination is both oral and written.

If progress of a student is found to be unsatisfactory he is sent to the ordinary schools.

All special schools are boarding schools.

(iii) Special Schools for Physically weak children :

There are number of such schools in USSR. They are boarding schools of sanitorium type and are located in the outskirts of cities where best environment for the improvement of health of children prevails. The main aim of the school is to provide expert medical, psychological and educational guidance to the children who are physically weak. The pupils receive education and acquire working habits for participation in socially benificial productive labour with their peculiarities taken into account. Here

health is not defined as absence of disease but as something positive. The care bestowed by the authorities on the children is so good that many parents desire to send their children to these schools.

(iv) Boarding Schools

Boarding schools are the general educational and teaching institution of a new type. There are number of boarding schools in all the republics of USSR. In these schools more propitious conditions for acquiring of Secondary and Polytechnical education, bringing up in the children high moral standards, providing of good physical and esthetic developments and preparation for practical activities in the various branches of national economy are created. To achieve these objectives the boarding schools in its teaching and educational work consistently couples school activities with life and unites education with the practical habits of independent work and application of knowledge are acquired by the students. In teaching and education work of boarding schools the training is combined with social work, with the diversity of working activity of pupils by elementary types of self service and economic domestic labour, children's participate in productional labour workshops and undertakings and collective farms. Here the age peculiarities are taken strictly into consideration.

(v) Special Schools for mentally retarded children

Children who are mentally retarded and whose intelligent quotients are low are admitted to these schools. The main aim is to minimise the abnormalities in these children and make them fit to take up general education. The programme of instruction in these schools is entirely different from other schools and is mostly suited to individual needs. Even

the teachers who train these children have a special course in a faculty of the Pedagogical Institute. This faculty is known as the *faculty of defectology*.

(vi) *Special Language Schools*

There are some special schools for teaching foreign languages like English, French, German, Spanish and Hindi etc. *The curriculum in these schools is the same as the* other Secondary Schools in regards to the other subjects. The children have facility to study one foreign language to a *greater depth* than in other ordinary schools (In all schools of USSR, children study their Regional language, Russian language and one foreign language). In these schools the foreign language is taught from the Second grade (eight years of age) and in other ordinary schools *the foreign language is commenced from the fifth grade.* As far as the foreign language curriculam is concerned it is richer than the one in ordinary schools. Besides, some topics in chemistry physics etc. are taught using the foreign language as the medium of instruction by the respective *foreign language teachers, although these topics are also* taught in Russian and in regional language.

In some schools experimentation is being done by teaching subjects like physics fully in English from the sixth standard.

(vii) Collective farm Schools

These are generally boarding schools started by collective farms and run by the State in *collaboration with collective* farms. These are located very near the farms. The collective farm out of its proceeds of income, builds buildings, the school teachers are appointed by the government and the recurring expenses are fully met by the government.

Every year the collective farm also gives a certain percentage of its income to the school and thus the School has extra advantages and grows faster

General Information regarding the Secondary Schools

A uniform state system of public education has been established in USSR consisting of the following main categories.

(a) General Secondary education with a variety of Schools.

(b) Specialised Secondary education.

The chief aim of the general school is to prepare the children for independent life and socially useful work. They also provide the background knowledge which is quite adequate for continuing their study at higher institutions of learning. The general secondary schools give education to children from the age of seven to seventeen or eighteen. The course of study in the highest classes (IX and X) varies depending upon the geographical, economic and social aspects of the region in which the. School is situated. Schools in farm areas for example link up their practical and theoritical training with agricultural production. There are Schools that place special emphasis on mathematics, chemistry, biology, foreign language and music etc. Special evening schools are run for young factory and farm workers who for certain reasons were unable to complete their Secondary education earlier. The educational system developed in USSR has produced millions of well informed citizens in a short period. Every citzen can be said to be *scientifically literate, science Stream is obligatory* for all students in secondary schools irrespective of what specialisation they intend taking later.

The curriculum in Secondary schools in all the repub-

lics of USSR is more or less similar and a student studying in a school of one republic will not have much difficulty when he migrates to a school in another republic. The Soviet Academy of Padagogy at Moscow prepares the curriculam for all the republics and these are adopted with minor changes by the republican academies of pedagogy. In Russian federation the children study Russian Language and any one foreign language like English, German, French or Spanish etc. In other Republics the children study Russian, their regional language and any one of the foreign languages mentioned above. It may be noted here that these children learn less of Russian language than the children in the Russian Federation.

In some of the schools general secondary education is coupled with a specialised secondary education also. There are net work of urban and rural school in all the republics. Whether the school is located in a village or a city, it is provided with good buildings and standard equipments to provide a rich and useful programme of instruction. They are more or less standardised in regard to equipment, library and dimensions of class rooms, laboratory and workshops. All schools have well equipped laboratories and workshops. In general there are two departments in each workshops attached to the Schools. These are carpentary and metal shop. Each of these sections are supervised by qualified instructions. Effective training is given to girls in different branches of domestic science and many sewing machines are provided to each schools. Besides these girls can get good training in typing, nursing etc For all these types of extra training special certificates are awarded to students on satisfactoy completion of the course. This can be considered as an *employment preparatory course in the school for the children.* All audio-visual aids and equipments needed for

programme instruction (radio, television, tape recorder projectors etc.) are provided in all the secondary schools in USSR. Some schools have even planatorium and the children have opportunities to study abstract things in a concrete way.

The Science class rooms are designed and equipped in a way that they serve as lecture cum laboratories. The desks of the students are fitted with gas and water connection in Chemistry, in Physics with electrical connections both A.C. and D. C. In all the laboratories and lecture halls the scientific atmosphere prevails. The advantage of this type of lecture cum lab. is when the teacher is explaining a scientific topic by demonstration method, the pupils can simultaneously do the same experiment and Dewey's philosophy of learning by doing is implemented Chemistry is what chemist do and the investigatory aspect of learning science is promoted by this technique. Each class room in science has an attached store cum preparation room and also balance room

The Mathematical Section of some school have computing centres staffed with engineers and tutors Mathematics is taught as a practical science and many student know how to work on electronic computer or calculating machines.

A School Library has about 12,000 books. This curricula of the secondary schools generally provide for the following school time distribution : 45% of class room time goes to humanities (Russian language, literature, history, society study, geography, foreign language drawing, music.)

37.5% of Class room time goes to natural sciences and

mathematics, Physics, Chemistry, Astronomy and Technical drawing. 11% of the class room time goes to general technology *subjects, labour education* and *up bringing 6.5% of* Class room time goes to sports.

All the subjects of the curriculum in a Secondary School are compulsory

Besides, to meet the individual inclinations and interest of the pupils and to foster their capacities and talents, provisions have been made for selective, optional subjects dealing with *the specific problems of science technology and arts.* In schools meant for industrial and agricultural workers the weekly class room time amounts to 22 hours, including *20* hours for general education and two hours to subjects relevant to vocational training of the student

The curricula of secondary schools give an idea of the content of education. The curricula defines practical skills to be mastered by pupils in the process of training.

All the secondary schools have a headmaster *who is in charge of the academic and the administrative aspect of the* school. He is assisted in his duties by a number of padagogical personal and most of these pupils have higher education in padagogical institutes The headmaster observes the teaching of his coolleagues now and then and suggests practical measures for improvement of teaching. The positions like that of headmaster are entrusted *to the most experienced and qualified teachers who carry out these duties* on a voluntary basis without any extra remuneration. Best teachers and [illegible] workers are also recognised by [illegible] national awards. Much preference is given about

the good work done by a school or by teachers so that these healthy practices are spread from one school to another. Groups of public inspectors and instructors in methods, as well as experts in public education, scientists and teachers of high schools have been established at the district, regional, city territorial departments of public education and at the ministries of education in the union and autonomous? republic to promote the growth of education and schools in methodical manner. Advanced padagogical methods in school practices have helped the teachers to improve the content organization and methods of education. The fact that 37% of the state and the central budget are devoted to education shows the importance attached to public education in USSR.

Each school has two committees to assist the authorities (1) parents committee—This committee is elected in the general body meeting of the parents in the beginning of the year, this committee co-operates with the school in making all educational programmes highly effective, and (2) students representative committee – Latter committee is involved in maintaining school discipline, co-curricular activities etc.

The following data illustrates the excellent progress made in public education in USSR and its republics: The number of those studying in Union Republics (in thousand).

Republics	In Gen. Education schools of all schools		In Higher Schools		In Secondary Specialized Schools	
	1914–15	1964–65	1914–15	1964–65	1914–15	1964–65
U.S.S.R.	9656	46853	127.4	3607.7	54.3	3325.1
R.S.F.S.R.	5684	25698	86.5	2212.2	35.4	2061.7
Ukrainian S.S.R.	2607	8524	35.2	643.8	12.5	593.5
Byelorussian „	489	1730	—	96.3	1.4	108.7
Uzbek „	18	2279	-	154.3	0.1	88.4
Kazakh „	105	2624	—	132.0	0.3	149.6
Georgian „	157	904	0.3	74.8	0.5	35.5
Azerbaijan „	73	1056	—	53.7	1.5	49.3
Lithuanian „	118	532	-	42.8	1.5	54.3
Moldavian „	92	738	—	33.4	0.5	28.7
Latvian „	172	342	2.1	31.4	1.8	36.6
Kirghiz „	7	583		29.0	—	27.1
Tadzhik „	0.4	535	—	26.0	—	20.1
Armenian „	35	492	—	33.7	0.1	26.6
Turkmenian „	7	402	—	18.5	—	19.2
Estonian „	92	214	3.3	19.9	0.2	25.8

Extra curricular activities have almost become co-curri lar because of the great role they play in developing the ilities skills and attitudes of children and meet the various eds of the child in cultural, social and scientific fields. eat importance has been bestowed on many non school ablishments like pioneer palaces, regional city centres, oneer houses, pioneer camps, centres of young naturalists, ildrens excurtionist and tourist stations and bases, children dium, palaces or sports and recreation parks. There is a cial unit called young technician's centre which aims not ly promoting interest but also in making the pupils attain ficiency. These non-school establishment have close nnections with schools. In all the republics of the Soviet ion there is an extensive net work of such centres for ldren. Millions of school children use their out of school urs in interesting and versatile activities. This kind of k for promoting the hobbies is gaining momentum and could see parents coming with teen agers in the ning time and morning to get their children opportunities develop their personality. Educational establishments, ntific and technical personal and public give both moral material help to create favourable cunditions to foster develop the inclinations and talents of youth. Most of teenagers and youth utilise their time very effectively hese centres and a number of olympiads and competitions conducted at various levels not only in sports but also he field of chemistry, physics, mathematics, biology home nce, tecnology etc. Many such libraries relating to a e varities of hobbies are attached to each of the pioneer ces. These non-school establishments also have very l equipped laboratories, workshops, tailoring section, matography section, photography section, cosmonaut tre, cooking centre, radio and television engineering centre almost equal to the level found in a well equipped

technical school or a college. In USSR, there are about 3334 palaces and houses of pioneers, 384 young technicians centres 287 young naturalists centres, 174 excursion centres, 2217 children sports Schools, 117 children and youths theatres, 182 children recreation parks and thirty three childrens railway lines. Works of fiction both Russian and foreign as well as periodicals and magazines on science technology music etc. are available in these centres. The children books publishing house alone puts out 12820 books at a total circulation of 1.66 million copies. In 1953, 2867 books for children of pre-school and school age were published. Even the school libraries have big sections devoted to extra curricular activities. A great deal of attention is being paid to aesthetic education also.

The activity of the out of school organisations is framed in close contact with the schools so that over working of pupils is avoided. Some of these organizations even render assistance to parents in bringing up the children in the families. The work in many of these establishments is directed by padegogical personal. The out of school organizations conduct versatile methodical work; seminars, consultations in practical studies, lectures, reading, conferences with teachers, with leaders of school groups, and with parents. They study generalised and propogate through press radio and cinema. Worthy experience of outstanding students or organizations.

Note — Authors of this article visited U.S.S.R. in 1963. The information given pertains to the [illegible] prevailing at that time. Since the education system in USSR is very dynamic, considerable changes might have taken place after 1963. For example the primary education has been [illegible] to three years in some parts of USSR from 1969. The total duration of primary & secondary schooling has become [illegible] years in those schools.

Science Teaching in India
(Efforts for Improvement)

N. Vaidya

Introduction

Science Education in our country is not a separate and 'detachable unit' of secondary education. It is several decades old but still it suffers from many defects. These defects are too obvious to mention here. Due to these defects, the result is that we have yet to go a long way in developing the Indian Tradition of Science Teaching at the school stage. The Secondary Education Commission (1952-53) was the first commission to survey the entire field of secondary education. It recommended the establishment of multipurpose schools to provide diversified courses at the end of the middle school stage. Highly qualified teachers and the teaching of specialized sciences at an advanced level were to be the outstanding features of the newly opened higher secondary schools. This radical departure from the past situation created its own problems which were considered by the various commissions and committees later on with a view to build quality into science education right throughout the school. Proceedings of the All India Seminar on the Teaching of Science in Secondary schools, Report of the Indian Parliamentary Scientific Committee, Position of Science Teaching in Indian schools', Science and Mathematics Education in schools (Report of UNESCO) and Kothari Commistion need special mention in this connection (10-16)

Efforts for Improvement

On reading these reports, one gathers the impression that we have been unintellectual, unthoughtful and lazy in our discussions and action. This impression, is however, *wrong* because problems facing science education in our country are both quantitative and qualitative in character. It has been now accepted in principle that these integrated steps are essential before we can expect real improvement in science teaching and education. These are :

(i) Development of a curricula, that includes modern concepts and understandings of the subject-fields and a rigorous, analytic study of fundamentals

(ii) Preparation of text books based on the new curriculum, teachers' guides/manuals and other instructional materials; designs of experimental kits and apparatus.

(iii) Training teachers and equipping them with the necessary competence to introduce the curriculum into the classroom.

Naturally, a radical programme of improving science education cannot be a short term affair. We have first to evolve experimental programmes for science teaching before *we can train teachers to introduce modern concepts* to our youngerters. Even then we have tried hard to lay the basic foundations necessary for building up an intelligent and impressive programme of science education by the end of the third five year plan. It is about these efforts that we will make a brief mention now.

(a) In 1950-51, we had 191.5, 31.2 and 12.2 lakhs of children in the elementary, middle and secondary schools respectively. The corresponding percentages in the three respective age groups (6-11, 11-14 and 14-17) having educational opport-

unities were 42.6, 12.7 and 5.3 respectively. These figures rose to 496 4, 97.5 and 45 6 lakhs of children and the corresponding percentages in the above mentioned age groups rose upto 76.4, 28.6 and 15.6 in the year 1965-66. In the third five-year plan, school science received considerable emphasis. By the end of the plan, the total number of high and higher secondary schools was expected to go up to 22000, out of them over 9000 offering science as an elective subject. The Scienec laboratories of about 6000 schools were expetcted to be further strengthened by providing them additional equipment. Moreover, a crash programme now undertaken ensures that all the secondary schools which were opened by the end of the second plan will be provided with laboratories on 100 p. c. assistance to States by the Centre outside their plan ceilings.'

The allocation went up from 105 crores of rupees in the first plan to 297 crores of rupees in the third plan both for elementary and secondary education. The above amount excludes expenditure already incurred for maintaining institutions before the beginning of the first plan and the contribution from non Government sources.

It is further proposed to strengthen science teaching both at the elementary and secondary stage : methods of science teaching, setting up of mobile audio-visual units, introducing and strengthening of General Science at the secondary stage, availability of elective at least at one school in an area lacking such facilities and provision for a small science library. It had been proposed to spend a sum of Rs. 500 millions for starting and strengthening science education in its varied aspects. This excludes the provision

of Rs. 100 millions for the National Council of Educational Research & Training activities. This expansion and the quality in the improvement of science education will naturally depend upon the availability of competent teachers, laboratory facilities and equipment production of text-books and other instructional and illustrative material.

(b) In the past. science meant only physics and chemistry. There was very little of biology teaching in schools. After the Recommendations of the Secondary Education Commission, opportunities for biology education became increasingly available in the newly opened multipurpose schools. In most of the States, optional sciences include physics, chemistry, biology, mathematics and geography. Other subjects included are geology (U. P., M. P., A. P., J. K.), and elements of physiology and hygiene, elements of home science, agriculture, geometrical and mechanical drawing and military science or drawing (M. P. & U. P.). All the States except Kerala prescribe varying degrees of practical work to be done by the students.

General Science is taught to all the children in the country upto the middle stage. At the higher secondary stage, it is compulsory in most of the States and optional in Telangana (A. P.), Marathwada, (Maharashtra) and Assam. In Bihar, the natural science students do not offer this subject. It is taught for the first two years (IX and X) in the States of Rajasthan, Punjab, Jammu & Kashmir, West Bengal and Maharashtra (Vidharba only). It is taught for three years in the States of Bihar, Kerala; Madras, Mysore and Marathwada (Maharashtra). General Science and not physics, chemistry and biology as separate subjects, are offered in Madras and Kerala. It is only in three States that the practical work in general science is assessed externally.

(c) Science needs laboratories and equipment. The Committee on Plan and Projects has suggested Rs. 4000/- including Rs. 1000/- for tools for equipping the science laboratory at the middle school stage. For a high school, the amount suggested is Rs. 10000/- including Rs. 1000/- for workshop tools. An extra grant of Rs. 3000/- is suggested, if biology is to be introduced at the high school stage. For recurring expenditure on science practicals including replacement, a grant of Rs. 10/- per student per year is recommended.

The UNESCO Planning Mission on Science Teaching has recommended the abolition of General Science. It has, on the other hand, suggested the teaching of physics, chemistry, biology and astronomy at the middle school stage. For this, it has recommended a total grant of Rs. 12,000/-.

Its break-up is as follows: — Physics Rs. 5000/-, Chemistry Rs. 3000/-, Biology Rs. 2000/-, Geology Rs. 1000/- and Astronomy Rs. 1000/-

At the higher secondary stage, a sum of Rs. 60,000/- is considered essential for demonstrations and laboratory work. Its break-up is as follows: —

Physics Rs. 25000/-, Chemistry Rs. 17000/- and Biology Rs. 18000/-.

At present, the States of Rajasthan, Punjab and Madhya Pradesh spend Rs. 12000/-, Rs. 10000/-, and Rs. 12200/- on physics, Rs. 8000/-, Rs. 10000/- and Rs. 9500/- on chemistry and Rs. 8000/-, Rs. 10000/- and Rs. 14400/- on biology respectively. For General Science and A. V. Aids, Rajasthan and Madhya Pradesh grant additionally Rs. 2500/- and Rs. 9500/- respectively.

(d) In addition to usual workshops, summer institutes are organized for the science and mathematics teachers every year in different parts of the country. By the end of the fourth five year plan, it is expected to train about 36000 teachers in science including mathematics. Further 21 study groups each *under the guidance of a senior university* professor have been set up by the N. C. E. R. T. in the *subjects of physics (6)*, Chemistry (5), *Biology* (5) and Mathematics (6) at well known universities and first rate *science institutions in different parts of the country to* develop an integrated system of curriculum materials in order to help teachers to achieve the 'correct understanding of concepts in physics, chemistry, biology and mathematics from a modern stand point and for an integrated understanding of the unity and totality of scientific knowledge'. It is proposed to test these programmes in the actual classroom conditions and Department of Science Education will serve as a focal point for the integrated development of a *total curriculum*.

It is further, heartening to note that under the auspices of the All India Science Teachers Association, a Physics *Study group sponsored by the National Council of Science* Education and National Council of Educational Research and Training *has* been set up to 'develop new and *integrated* curriculum materials in physics at high school level, embodying the modern approach and *fully utilizing indigenous* resources'. It came into existence on Jan. 1, 1968 at the Doon School, Dehradun in U. P.

This idea has been now further developed at *the* Regional College of Education, Ajmer under the directorship of Principal P. D. Sharma and Dr. A. N. Bose (R. C. E. Ajmer) a steering committee has been set up to device a training programme for the Science Club Sponsors of the

ntire northern region with a view to build quality into science fairs as well as investigative projects. About 150 science club sponsors from the northern region have been trained at the R. C. E. campus. This Science Youth Project was financed by the U. S. A. I. D. It has been decided tentatively to start this project at the remaining three Regional Colleges of Education if the project at the R. C. E. Ajmer shows fruitful results.

(e) It is a general and common criticism that the teaching of science in Indian schools is largely bookish and theoretical. Science clubs were first set up in the year 1957-8 by the former All India Council of Secondary Education. There are now about 1000 science clubs and 92 central science clubs in the country. Each science club at the school is given a sum of Rs. 1200/- (now the practice has been discontinued) to augment the school's meagre resources only for the purchase of tools and equipment. Their basic aim is to encourage scientific thinking and develop scientific aptitudes, particularly among science students. They are, generally speaking, organized on a voluntary basis (8). Their activities range from preparing charts, holding debates and discussions, and organizing science fairs in collaboration with other science clubs, to the construction of some scientific apparatus and participation in an original project. Dr. Irwin Resnick, formerly Science Consultant at the Regional College of Education, Ajmer developed experimentally through Mobile Science Show a book which will provide ideas for science students on some original projects. This book (Research Ideas for Science Students) is available free of cost from the Principal, Regional College of Education AJMER.)

(f) There are other efforts which directly and indirectly contribute to the quality and improvement of
...m : science competition essays in

last twenty years, science talent search in vogue in West Bengal for the last six years or so for the first year students at the University, appointment of Science Consultants in the State Departments of Education for providing expert advice and help to the science teachers for the last seven years or so, appointment of science Inspectors in Andhra Pradesh and Mysore for guiding and supervising science instruction, establishment of the four Regional Colleges of Education for producing competent teachers in the fields of science, technology etc. (internship in teaching being their distinctive and distinguishing characteristic, and the establishment of State Institutes of Science Education in the third plan, and lastly, the publication of two journals, namely, the Vigyan Shikshak and the School Science, published by the All India Science Teacher's Association and the Department of Science Education, NCERT, New Delhi.

(g) It was about 10 years ago that the All India Science Teacher's Association under the (still continuing) Presidentship of Dr. A. C. Joshi ex. Vice-Chancellor of the Banaras Hindu University (and formerly Adviser to the Planning Commission, the Vice-Chancellor of Punjab University and the Director of Education, Punjab) was formed. The aims and objectives of this association are to improve the standards of school science instruction, to spread scientific information and foster research in the methods of teaching science. It is a voluntary organization and focuses the nation's attention on the various deficiencies in our science education at its annual Conferences every year (7).

(h) A comparatively much richer and resourceful nucelus, the Department of Science Education and one of the departments of the National Institute of Education (NCERT) was established in 1961 with a view to changing the total face of science education and teaching in this

ountry. Over a reasonable period of time, it aims to generate an effective climate for effective school science teaching The following are its areas of work :

(a) Curriculum material including text-books, teacher's guides, laboratory manuals, preparation of syllabi and supplementary reading materials, etc.

(b) In-service education:—Summer Institutes for science teachers in collaboration with U.S A I.D, and the U. G. C., to organize workshops and courses for Science Consultants and Science Inspectors and the organization of training courses for the preparation of resource personnel at the elementary level.

(c) Publication of the School Science journal for disseminating information regarding scientific advances, methods of teaching science and book reviews etc.

(d) Establishment of science clubs and providing technical and financial help in the organization of science fairs.

(e) Equipment and apparatus: To provide help and advice in setting up laboratories and purchase of equipment including preparation of suitable inventories for the same.

(f) Central workshop for improving and constructing scientific apparatus, preferably cheap.

(g) Laboratory for the department to tackle problems in science education experimentally and constantly to improve science teaching.

(h) Organization of workshops and seminars.

(i) Instructional materials centre for teaching aids and reference material.

(j) Science statistic centre to collect the relevant information.

(k) Research in science education.

(l) Science talent search scheme for identifying gifted students in science at the higher secon-

not excluded. The coordinating function is done b department of science education. They have so far comp the following tasks: three textbooks and three teac guides for the middle school stage (*Biology Grou* laboratory manuals, a textbook in chemistry, and guide (Chemistry Groups); two draft manuscript c textbook and a student's work for the first year of school (*Physics Groups*); and *draft manuscripts metry textbook along with the teacher's guide and* t in progress for algebra and arithmetic subjects (Matl Groups). These curricular materials will be given in some selected schools. All the groups are currentl *loping materials in various science subjects including matics for the higher secondary classes and the entire* is likely to be completed by the middle of 1970.

activities for providing to the children individual and group experience in science.

(iv) To develop instructional materials for classes III to X based on the above syllabus for the use of students and teachers. The instructional material shall consist of text-books, work-books, laboratory manuals and teachers' guides.

(v) To develop instructional materials for the pupil-teachers for the pre-service programmes.

(vi) To develop and organise-short term re-orientatation-cum-training courses in content and pedagogy for science educators in the teacher training colleges.

(vii) To organize, through a phased programme, in-service training courses for selected existing elementary and secondary school teachers with a view to improve their competencies to enable them to handle the revised science syllabus.

(viii) To prepare detailed lists of equipment and other teaching aids with their specifications if possible and to provide these materials to the State Institutes, teacher training institutions and selected schools where the re-orgnised programme will be introduced.

(ix) To provide simple tool kits to teacher training institutions and secondary schools to enable the staff and students to develop the necessary skills for improving and repairing science equipment.

(x) To provide laboratory and library facilities to the State Institutes of Education and Science, teacher training colleges and teacher training schools for handling an-improved pre-service and in-service training programme for science teachers.

(xi) To develop and produce simple science kits and demonstration and laboratory equipment for the effective teaching of the new courses in Science.

(xii) To introduce *the revised syllabi* and *instructional* material in the schools, depending on the *conditions prevailing in different States* and according to their needs, and lastly.

(xiii) To provide a mobile laboratory-cum-projection equipment unit to States for experimental teaching of science and the in-service training in the district.

One of the distinctive features of this project is that 'due emphasis will be given to the inclusion of elements of health and nutrition education as part of the total general education programme, especially at the primary and also to some extent at the middle stages'. Further, the 'facilities made available by the Government in these fields through *specific rural health, sanitation and applied nutrition programmes* implemented with UNICEF assistance, will also be utilized, wherever available.' For the first two years of this project, the UNICEF and the Govt. of India will provide funds to the extent of 2, 182,000 dollars and 110. 87 lakhs of Rupees.

The Department of Science Education is very active. There are still another Textbook Panels and Editorial Boards who have published improved textbooks for the higher secondary classes in science and mathematics with up-to-date and accurate content matter. Whatever is not covered is covered under other Departmental Projects. Under this scheme, *eight titles have been selected*, a *few are out*, and others are in different stages of processing.

India cannot survive for long on mediocrity at the *top*. This is also true in case of science. We must therefore aim at the 'highest education of the highest intellectual.' *Another exciting, imaginative* and *fascinating* activity of the Department of Science Education is to catch talented science students at *the close of their secondary education*. As a pilot project, the scheme was first tried out in the

Union Territory of Delhi in 1963. In the succeeding year, it was extended all over the country. About 350 scholarships are awarded each year on the basis of tests : aptitude test (formerly 125 and now 100 marks), essay (50 marks); project report (25 marks) and interview (50 marks). The total number of competitors for this scholarship is over 6000 except in 1966 when it was 4065. One out of eighteen or nineteen gets the award. All awadees do not avail the award, that is, about 30 percent or so drop out of this scheme. This is very serious in case they happen to be the near tops. This scholarship is quite tempting for its period has now been extended to nine years, that is, one hundred rupees for three years of the B. Sc. course, two hundred and fifty Rupees for two years of M. Sc. course, three hundred and fifty rupees for doctoral work for a period ot four years, and other fringe benefits like grant for books, reimbursement of tuition fee and participation free of cost at the summer school in one's field of specialization. The main objectives of this scheme are :

(i) To identify boys and girls at the close of secondary stage who possess a marked aptitude for science and mathematics ;

(ii) To stimulate scientific talent by a competitive process and recognition of merit;

(iii) To help such students to pursue courses in basic sciences by the award of scholarships from B.Sc. to Ph. D. stage;

(iv) To provide special programmes in science to such scholars with a view to nurture the talent ;

(v) To encourage schools to take more active interest in the search for scientific ability ; and lastly

(vi) To help in building up a body of scientists who will contribute to the scientific advancement of India both in pure and applied fields.

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(xiii) To provide a mobile laboratory-cum-projection equipment unit to States for experimental teaching of science and the in-service training in the district.

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Certain other outcomes are also expected to emerge o of this programme, the most important of which are:

(i) To create a consciousness for improving the syllabi of science subjects, methods of teaching and evaluation techniques;

(ii) To provide colleges, universities and technical institutions with a means of contacting science students of high ability; and

(iii) To mobilise the interest and support of higher centres of learning and other science agencies for the development of scientific talent.

Lastly provision has been made from 1968 onwards for awarding a limited number of scholarships for those competitors who show exceptional promise in mathematics. A radical change in the medium of examination has been made, that is, from 1969 onwards, the examination will be conducted in addition to English in all the regional languages recognized by the constitution. The objectives of the scheme can be achieved if other agencies like the institutions of excellence as selected by the U. G. C. co-operate in this venture. This side of the picture is grim as is borne out by a Report of the Science Talent Search Examination of 1966.

Thus it will be evident that this National Scheme has been designed to fulfil an important need of the country, i e. to provide basic scientists to the various national laboratories, defence establishments, universities and allied institutions. The industry will also be ultimately benefitted through the academic net-work of this scheme.

The results of the follow-up studies have not been very encouraging because of many obvious reasons. The students who get the National Science Talent Search award are ultimately admitted to such institutions where age-old traditional curricula, methods of teaching, and evaluation exist. Secondly

there are hardly any opportunities for talented scholars to work independently on themes of their choice. The load of memorisation is so heavy that it seems impossible for brilliant scholars to do any original work based on creativity and intellectual sagacity. These are some of the facts of reality which cannot be over-looked while analysing the results of this National Scheme.

Mentioned above is a highly disturbing statement which has clear implications for other programmes of the Department of Science Education.

There is also an Instructional Material Centre of this Department which not only acts as a clearing house for information on Science Education but also aims to disseminate the creative and useful work done by the science teachers to improve the quality of science teaching in schools of the country by developing and producing new instructional material in science. The informative brochure prepared by this department provides practical as well as consolidated information regarding science kits and their sources, science models and toys and their sources, manufacturers of laboratory equipment dealing in laboratory fittings and furnishings, availability of scientific films including film strips on loan for a short period of time, science journals and periodicals, books on methods of teaching and instructional materials based on new science curriculum developed by the Department of Science Education and Study Groups of NCERT for the use of science teachers and administrators of schools and teacher training institutions.

The department also provides technical assistance to the Ministry of Education, the Planning Commission, the State Institutes of Science Education and other bodies. It also provide financial as well as academic assistance to the professional bodies of science teachers, and institutions in

the conduct of their science education programmes. It also publishes a quarterly journal : School Science and deals with modern developments in science and science education.

From the above sketchy account, it appears that the Department of Science Education is doing quite a creditable work at the national level. It is also generating lot of curriculum materials for use both by the students and teachers right throughout the school. This is a very healthy sign if it does not increase confusion at the end of the journey. There is an urgent necessity now for bringing in psychologists and method specialists into the picture for studying the impact of these new curricular programmes on the young minds, in the context of their widely differing educational environments. For this purpose, the new programmes need to be tried out on a big scale under all possible classroom situations for improving their effectiveness. Different methods of teaching, currently available, need to be tried out on big scale. Funds for the same, of course, are required. Appropriate home work and research can save us lot of money later on. At present, the Department of Science Education looks content oriented but it ought to be a compound of science and education, sharing neither solely the properties of science nor that of education.

Our talented science students appear to be inferior to none in the world provided someone is able to identify and pick them up for advanced training at an earlier age. In 1964-65, it was, therefore, decided to start summer schools for the awardees of the science talent search scheme. The main objectives of these summer schools are:

(a) To establish inter-personal contacts between the teachers and the taught;
(b) To enable the talented students to develop their intellectual potentialities in the best possible way;

(c) To motivate the experimental curiosity of the students so as to stimulate the creativity and research spirit;

(d) To enable the promising students to exchange views with their class-fellows and thus to promote a greater understanding and appreciation of each others' views;

(e) To enable the talented students to develop new basic concepts in their fields of specialization;

(f) To encourage the scholars to pinpoint their academic interests and aptitudes; and

(g) To produce an accelerated programme of science education.

The programme at the summer school comprises lecture work, laboratory work, project work, film shows, excursions and workshop practice. Recently twenty three Science Talent Search Scholars attended a summer institute at the Indian Institute of Technology, Kanpur in U. P. All of them had completed the first year of the three year degree course in science and 'intended to pursue careers in mathematics or physics'. Their academic course completed over a period of about four weeks comprised courses on Number System, Basic Mathematical Structures, Linear Programming and Matrices, Vector Analysis, Fortran, Programming (A short course), and perhaps the most enjoyable. Problem Solving Sessions conducted by Prof. J. N. Kapoor, Ten special lectures by distinguished scienctists and mathematicians, visits to aeronautical engineering laboratories and computer centre were also arranged. Further, each participant was expected to complete a project. Some of the advanced projects completed by the participants were on: 'Groups of Symmetry, Magic Figures, Arithmetic in Binary Scale, Mathematical Induction, Theory of Games, Dynamic Programming, A New Approach to Number System and Ancient Indian Contributions to Mathematics' (9). These

are laudable efforts in the right direction (which need to be publicized for inspiring others) provided their level of intellectual functioning fed through too much direct information is not constipated. They should be able to chew and assimilate this material in a permissive and reflective atmosphere. Fifty one summer schools of one month duration in different science subjects including mathematics have been organized so far for the benefit of the science talent scholars

(j) Science Community Centre is in imaginative ferment at work in Ahmedabad which needs a mention because it may capture the imagination of many educational institutions in the entire country. It is an 'activity of the Nehru Foundation for Development for providing facilities and developing programmes for the understanding of science by students, teachers and the lay public and for the improvement of Science and Mathematics Education at all levels'. The centre will provide facilities and services like: laboratories, workshop, consultation and availability of expert advice, maintenance of a science museum, preparation of audio visual aids, publication work, gifted student programmes, and the conduct of seminars, workshops and inservice programmmes for teachers through week end discusssions, refresher courses, summer and winter institutions. It is interesting to note that a group for the improvement of science education, more popularly called CISE has been formed which needs regularly to 'discuss specific problems and projects which could be implemented in the near future.' For everybody whatever may be his age, ability, experience and interest, there is something to do. Consider their core programme. To quote director K. B. Shah:

> In order to make science a living, meaningful experience for the Science Centre participants, the local scene and life patterns must be the backdrop, as Dr. Sarabhai has aptly put it, against which the

drama of science is presented and understood. All levels of participants, elementary, secondary and college students as well as teachers and the lay public, will find within the core programme, interests, degrees of complexity and refinement at whatever quantitative and/or qualitative levels that will fit their needs and abilities.

Attempt will be made to develop the following behaviour among the participants : proposing problems, formulating and reformulating problems, setting up hypotheses and testing them through control experiments, uncovering new relationships, searching for proof and adherence to ethical standards and values (Elementary Level); designing projects, collecting, measuring, classifying and assessing data (Higher than Elementary); and describing experience, understanding experience and creating experience (9).

(k) International help : This is most welcome. At present, we are obtaining help in varying degrees from U. S. A., U. S. S. R., U. K. (The British Council and the Commonwealth Education Liaison Unit) and UNESCO. We send our science personnel abroad and experts from the above agencies visit our country and advise us on the problem facing us. In a way, it is a sign of dependence if we receive too much help from them simply for the asking. Here we should not forget a Tamil saying : "However hard the woman may cry, she has to deliver the baby herself. We must learn to solve our problems unaided.

(l) Effective leadership. Science Education in this country appears to be like a living body without a head. The prospectus for effective leadership are now brighter than at any time in our past history provided someone is able to give the diverse efforts a shape. In this respect, we hardly need to mention the following : All India Science Teacher's

Association, Department of Science Education (NCERT), Departments of Science in the Regional Colleges, Curriculum Panels, the State Institute of Science Education, the Science Educators in Teacher's Training Colleges, Senior Science Teacher at the Multipurpose Higher Secondary Schools and individuals like Dr. A. C. Joshi, S. Nataranjan, Dr. S. C. Shukla. Dr. D. S. Kothari and V. N. Wanchoo to mention only a few. Even the National Council for Science Education can take up this leadership. Recently, it was set up by the Union Ministry of Education to upgrade and improve science teaching (other subjects being mathematics, engineering and technology) at all levels to bring them at par with other advanced countries. The agreement in this connection was signed on November 1. 1966 with the United States Agency for International Development.

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Emerging Trends in Science Education

J. K. Sood
A. N Bose

Course improvement projects are underway in almost all nations of the world that have arisen in the last fifteen years. These efforts lay emphasis on the quality rather than quantity. *Education and the Spirit of Science* (1966 NEA) has defined new values of science teaching which affects the very texture of classroom teaching. This demands new philosophy and new aims of science education which have its ultimate relevance to the promotion of the spirit of science. Science, which is intellectually stimulating; scientifically authentic and helps in the development of rational powers of children, is the very essence of education. In this light many nations developed their own materials and many tried to adapt and adopt the materials developed by others. All this depends on the social and economic conditions of the nation in general and availability of sufficient funds and expertize in particular.

In advanced countries the changes are so rapid that it is impossible to record all that is going on in the classrooms; research laboratories and at the science teaching centers. Even then certain definite trends emerge from these efforts which are acceptable to many developing nations. This paper is an attempt to summarize some of the trends in Secondary Science Education.

I. Place of science in total education

In this scientifically oriented society it is assumed

that citizens should have functional understanding of science. This is an essential part of education for active participation in the functions of the society. Hence,

a. Science should be a definite part of general education since early beginning.

b. Students should get knowledge of contemparory developments of science, and sophisticated concepts at the lower grades should be taught.

c. Academic professors should collaborate with science teachers and science educators in presenting up-to-date content.

d. Content improvement needs periodic, continuous and rigorous evaluation. The purpose is not only clearing out of the dead material but there is a need to 'refurbishing and restocking the content.

2. Contributions of Research on learning

Many psychologists contributed to our understanding of how a particular type of learning takes place. A few workers tried to establish some relationship between learning and the developmental stages of children. These efforts demand:

a. New designs in curriculum development. Specifically sequencial developmnet of the science curriculum from K-10.

b. Proper spacing of the learning activities keeping in view the developmental stages of children.

c. Creating provision for individualized instruction.

d. More care of the creative children.

3. Use of Instructional technology

Last two decades have witnessed the application of

technology in the classroom. More and more audio-visual aids are available for teaching science. Variety of instructional materials are available which are being used for supplementary purposes. Hence:

a. A science teacher should use different teaching aids (films, film strips, slides, models) which will relieve him from his heavy schedule of work.

b. Use of programmed learning, lay emphasis on specification of objectives, individualized instruction, and evaluation is taken as a part of the whole programme.

c. Use of kits and 'package deal' is in vogue.

d. There is general trend to include more laboratory work.

4. Continuous teacher education programme

These new innovations demand a 'new teacher acquainted with all new philosophy and with skills of using the new materials. Therefore :

a. A continuous in-service-programme should be organized for science teachers.

b. Teachers should be a party in the preparation of developmental programmes.

c. Teachers should conduct research to findout the efficacy of new programmes.

d. New teacher education programmes should be developed which will bring a change in behavioural patterns of teachers.

In the Indian situation at present it is difficult to provide quality instruction in science education which prizes unconventionality, openness, spontaneity, curiosity, and novelty. Yet, we hope to provide the minimum, namely, spacious schools, qualified science teachers, equiped laboratories, books and other instructional aids.

III

SCIENCE IN THE CLASSROOM

At the earlist level of instruction, the individual needs to learn how to observe, how to figure, how to measure, how to orient things in space, how to describe, how to classify objects and events, how to infer, and how to make conceptual models. These capabilities he will use all of his life.

Robert M. Gagne

"Learning Requirements for Enquiry."
Journal of Research in Science Teaching,
Spring 1963.

Teaching and the Nature of Science

Willard J. Jacobson

Our teaching should be consistent with the nature and structure of the area or discipline being taught. As we work with children in science, the demonstrations, experiments, projects and other science activities should be developed consistent with the nature and structure of science.

The nature and structure of science can be compared with the framework of a building under construction. A framework characteristically has vertical pillars that are being extended upward. The pillars are interlaced with horizontal beams. The upper beams serve as platforms on which the builders use the tools of their trade to extend the framework. The framework is built on a solid foundation firmly rooted in the underlying earth.

Scientific activity is taking place. As the methods of science become more and more refined and sophisticated, it becomes harder and harder, but more important, for the teacher to explain the methods and the results of the use of these methods to children, students and the public at large. The rapid expansion and development of science is making it ever more important that the children in our schools gain some understanding of the nature and structure of science. To do this, our approaches to teaching must be consistent with the nature of science.

The Processes of Science

Certain processes or approaches are characteristic of

work in the sciences. Scientists do not use these processes and approaches at all times in their lives, but they tend to use these methods when they are operating scientifically. Usually, these scientific procedures are used when they are operating in their area specialization. A physicist is more likely to operate scientifically when he is dealing with questions and problems in physics than when he is dealing with difficulties in his home or business, although he may use them under those circumstances as well. The methods and approaches of science are among the most powerful intellectual tools man has developed, and it is especially important that children begin to gain some understanding of these methods. The statements that follow are important characteristics of science. Examples for each of these characteristics have been drawn from the history of science. *In science the primary test of an idea is an empirical one of "Does it work when it is tried?".* Whenever possible, ideas in the sciences are checked by direct observation or experimentation. Usually, it is desirable that the observations and expriments be checked by a number of scientists who are competent to carry out the observations and experiments.

An excellent example of the empirical test of an idea is to be found in experiments of the Italian scientist Redi as he studied the origins of the worms and flies to be found in refuse and manure. Prior to Redi's work in the latter part of the 17th century, it was commonly believed that dead bodies, filth, or any sort of decayed matter engendered worms. Redi placed three dead snakes in a box to decay. Worms soon appeared and began devouring the meat. However, the worms were of different sizes which led him to believe that they had been born on different days. In order to find out what happened to the worms, Redi repeated his observations using a box in which all openings were closed. He noticed the worms changed into egg-shaped objects which

we now know are pupa. After a number of days, adult flies emerged from the pupa. Then, Redi had an important idea: "Perhaps all worms found in meat come from flies, and these worms, in turn, develop into new flies !"

Redi went on to test the idea that all worms found in meat were derived directly from the droppings of flies by conducting a *controlled experiment*. He placed various kinds of meat into eight wide-mouthed flasks. Four of these flasks were sealed so that no flies could get near them, while the four remaining flasks were left open. Worms soon appeared in the open flasks, and flies were seen entering and leaving at will. No worms appeared in the closed flasks. By careful observation and controlled experimentation Redi obtained empirical evidence to test his important idea. The work of Redi and others laid the foundation for the important scientific generalization that living things come from other living things.

This insistence upon empircal tests differentiates science from several other areas of human endeavor. For an idea to be consistent with widely held dogma or pervasive beliefs is not an adequate test in the sciences. Similarly, majority vote is of little consequence. The old folk saying that "Forty-million Frenchmen can be wrong" holds for all nationalities. To test an idea in the science is to subject it to the rugged, demanding check of "whether the idea works when it is tried."

Hypotheses or suggested answers are used as tools to investigate questions and problems. Hypotheses are suggested answers to questions or problems. Observations, experiments and investigations are carried out to test hypotheses. Charles Darwin is reputed to have said, "How odd it is that anyone should not see that all observation must be for or against some view, if it is to be of any service." In other words,

hypotheses are intellectual tools that help us to guide o
observations and investigations.

An automobile mechanic uses hypotheses to investiga
why an automobile will not start. Obviously, he cann
check the entire automobile all at once. Instead, he sugges
possible answers and then checks these answers. For exampl
he may say, "Perhaps there is no gasoline in the gasolin
tank." Or, "Perhaps there is no spark across the gaps o
the spark plug." Such suggested answers are intellectua
tools that the mechanic uses to discover what is wrong wit
the automobile.

There are many, many examples of how hypothesis *have been used in scientific investigations, but one of the most striking examples is given by Charles Nicolle of the* way in which he discovered how typhus is transmitted. Nicolle often visited one of the hospitals in Tunis when there were patients suffering from many diseases, including typhus. However, it was well-known that, while typhus was very contagious outside the hospital it seldom if ever was spread from patient to patient within the hospital. Why? One day Nicolle noticed, at the entrance to the hospital, a body that had fallen victim to typhus. What was the difference between the pathetic dead man and the patients inside? The patients had been stripped of their clothing, shaved and washed. Typhus must be carried by something on the outside of the body. Most assuredly it was the body louse. Once having gained this idea, Nicolle proceeded to prove that typhus was transmitted by the body louse and showed how this deadly disease could be controlled.

Controlled experimental tests are an important means of investigation in the sciences. In the classic type controlled experiment, all factors but one are controlled. Any changes that take place must be due to the variable factor. When

new kind of seed is being tested, plants from the new seed e compared with plants from other varieties. However, is important that all varieties be grown under the same nditions of soil, water, sunlight and cultivations. If all ch factors are controlled, any differences in yield must be ie to the variety of seed used.

The *control* is an important factor if the experiment to be a scientific one. "It has been shown through undreds of experiments that the beating of tom-toms will ring the sun back after an eclipse." Of course, the sun lways does make an appearance again after an eclipse, ut this has nothing to do with the beating of tom-toms. controlled experiment helps to show what factors are nportant

Children should have may experiences in setting up ontrolled experiments. For example, one group of youngters wished to find out whether a dull, dark coloured surface vould absorb more heat than a shiny surface. Then they ut equal amounts of sand into the black test tube and into clear test tube. Thermometers were inserted into the sand n both test tubes and the test tubes were supported in front of a gooseneck lamp The children tried to make all conditions for both test tubes the same (distance from lamp, mount and kind of sand, etc.), except for the colour of the ube. Any difference in the temperature of the sand must be due to the colour of the tube It is especially important that children have experiences in controlling all but the variable factor in the experiment.

Science has a cumulative dimension. Isaac Newton is reputed to have said, "If I have seen farther, it is because I have stood on the shoulders of giants." Our scientists, today, build on the work of their predecessors. Similarly,

in science, our children need not start where the cavemen started. They can make use of the knowledge laboriously acquired by scientists of the past and present.

The work of Michael Faraday provides us with an excellent example of how scientists build on the work of others. Faraday discovered how to use magnets to generate electricity. However, he could not have made this discovery without such contributions as the following:

Volta	: Developed the voltaic cell which is a dependable source of electric current.
Oersted	: Demonstrated that an electric current flowing through a conductor will effect the magnetic needle of a compass.
Arago	: Showed how an electromagnet could be made.
Ampere	: Showed that two adjacent wires will be effected when electric currents are sent through them.
Unknown	: Showed how electric conductors could be insulated.

All of these contributions were essential, and they made possible Faraday's extremely important discovery.

Children can "crawl upon the shoulders of giants" by making use of books and other science materials available to them. A group of fourth graders was making a study of meteors and meteorites. Although one of the children had a relic of what was supposed to have been a meteorite, there is a limited amount of information that can be gained from the examination of a part of one meteorite. To augment this information, they scoured all the books that were available to them in the school and public library. With

the aid of these sources, they were able to develop a report covering much of what is known about meteors and meteorites. Early man regarded meteors with ignorant awe and fearful superstition. Because a great deal of cumulative knowledge of science is available to children, these fourth graders were able to view meteors with scientific understanding

Ideas and findings in science are criticized and checked by others competent in the field. In science, imaginative, new ideas are important, but these ideas must be subjected to the critical scrutiny of one's colleagues. When Copernicus published his heliocentric theory that the planets revolved around the sun, the theory was subjected to very severe criticism. Now, however, this theory with some modifications, is generally accepted by all astronomers. This public dimension of science provides for a series of checks and balances. It was not sufficient that Copernicus publish his theory; the theory had to be examined, criticized, and finally accepted by others competent in the field.

Experimental findings must also be checked by other scientists. In practice, this means that the results of an experiment must be accompanied by descriptions of the experiment that are sufficiently detailed so that other scientists can repeat and check the experiments As a result of some very important experimentation, the German scientists Hahn and Strassman reported that Uranium 235, when bombarded with atomic particles, split into such elements as barium and krypton. It was quickly realized that if uranium actually fissioned in the way, a great deal of energy would be involved and that this energy might be released in an explosion. When the fissioning of Uranium 235 was reported at a scientific meeting in the United States, it is reported that the scientists didn't wait for the close of the meeting before rushing to their laboratories to begin checking the findings of Hahn and Strassman.

"No one can work as a scientist in complete isolation from other scientists." Ideas and findings are communicated to other scientists to be checked and criticized. Obviously, this means that freedom of communication is essential in science, and restrictions of the freedom of speech and publication inhibit the continued progress of science.

Children should have a chance to communicate their *ideas and the results of their experiments to other children* for discussion and criticism. One of the ways to do this is to hold "colloquiums" where children describe their work in science, whether it be studies of how to grow plants in various kinds of soil or investigations into ways of building telegraph sets, to schoolmates who also are keenly interested in some aspect of science. The children have to prepare their *colleagues. Usually, the teachers helps to bring out the* most important points connected with the demonstrations. This is one way for children to learn a great deal of science in the traditional sense and, of equal importance, gain a more profound understanding of the significance of the "public dimension" of science.

One of the important approaches in science is to try to view questions or problems in new and different ways. Irving Langmuir improved the electric light bulb by approaching the problem in a radically new way. The first light bulbs were made by putting a carbonized filament inside a glass bulb and evacuating the air from within the bulb. Subsequent attempts to improve the light bulb often took the form of trying to pump a greater fraction of the air out of the bulb. *Langmuir considered other ways that the filament* could be kept from burning. Rather than pumping air out of the bulb, why not pump into the bulb an inert gas which will not support burning ? This was done, and a better light bulb resulted. Langmuir succeeded because he viewed the problem in a radically new way.

The idealized experiment has been an important tool in the sciences. Galileo used such an idealized experiment to achieve a better understanding of motion. If you push a cart along a level road, it will continue to roll for a short distance after you have stopped pushing. If the road is very smooth and the bearings well lubricated, the cart will roll farther before it stops What would happen if the road were perfectly smooth and there were no friction ? The cart, would continue to roll forever. By using an idealized experiment such as this, Galileo helped achieve a better understanding of the nature of motion. Later, Isaac Newton stated this finding as one of his laws, "A body at rest tends to remain at rest and a body in motion will tend to remain in motion in a straight line unless acted upon by an outside force."

To view questions and problems in new ways is difficult. "In this connection it is not irrelevant to note that, of all forms of mental activity, the most difficult to induce even in the minds of the young, who may be presumed not to have lost their flexibility, is the art of handling the same bundle of data as before, but placing them in a new system of relations with one another by giving them a different framework, all of which virtually means putting on a different kind of thinking-cap for moment." (1) Taking a point of view directly opposite to the prevailing point of view, as Langmuir did, and the idealized experiment of a Galileo are two approaches that we can help our children to use.

In science an attempt is made to express ideas and findings as precisely as possible. This usually means that, whenever possible, ideas and findings are stated in mathematical terms. For example, if children try to determine how many seeds in a package of seeds actually germinate, one kind of answer would be "many or most" "few or not

between these phenomena and explain them. Of course, the law of gravitation has been a powerful tool for investigation. In fact, the planets Neptune and Pluto probably would not have been discovered without the use of the law of gravitation.

Much of our work in elementry school science deals with the broad pervasive generalizations of science, and these become a part of any book in science. The following are examples of some of the most important generalizations of science. One generalization is drawn from each of the broad areas of science.

The conservation of matter and energy. The law of conservation of matter and energy states that *the sum total of matter and energy for any system cannot increase or decrease.* Under all ordinary conditions for practical purposes we can say "matter cannot be created or destroyed" and "Energy cannot be created or destroyed." Under unusual circumstances in particle accelerators such as in cyclotrons, where particles of matter are accelerated to velocities approaching the speed of light, the particles of matter increase in mass as energy is converted to matter. In nuclear reactions, matter is converted to energy. Except under these extraordinary conditions, matter and energy can be neither created or destroyed.

The law of conservation of matter and energy is of tremendous importance in the sciences. It means, for example, that when two or more chemicals react in a test tube, in a burning match, or in our bodies, the mass of the products of the reaction will be the same as that of the ingredients. When we use a machine to do work we know that we will not get any more energy from the machine than we put into it. In some ways, the law of conservation of matter and energy shows us some of the limitations to what we can do?

n the other hand, the law is a powerful tool for predicting hat will happen when we carry out certain operations.

The law of conservation of matter and energy is often nderstood in an unsophisticated, but important way, by hildren as they say, "you can't get something for nothing." 'he law is used in a more precise way when we use it in alancing chemical equations or in calculating the efficiency f machines. In any case, it is an important tool for the tudy and understanding of the matter and energy in our nvironment.

The second law of thermodynamics: The second law f thermodynamics states that *heat can never be transferred pontaneously from a colder to a hotter body*. If some object uch as a bar of metal is heated, the heat will be transferred way from the hotter region to the colder, it will not move pontaneously from the colder region to the hotter. In refrigerators, air conditioners and similar devices, heat is 'pumped' from a colder region, such as the interior of a refrigerator, to a warmer region, but energy has to be supplied and work done. If a refrigerator, is disconnected so that no energy is supplied to operate the compressor, the temperature inside the refrigerator will eventually become the same as that outside.

The science of thermodynamics is largely a study of the application of the second law of thermodynamics. In our homes and schools we use insulating materials to slow down the inexorable transfer of heat from the warmer region to the colder. On the other hand, we design our heating systems to accelerate the process of transfer of heat. Children study this law of thermodynamics as they measure the changes in temperature in solids, liquids and in the air around them and as they investigate ways that heat is transferred in homes and throughout their environment.

Like the law of conservation of matter and energ the second law of thermodynamics is a major pillar in th framework of science. It is a law of limitation in that i dictates to us certain operations that cannot be carried out We cannot expect to have a spontaneous flow of heat energ from a cold region to a hot region If we want this to take place, we must, in some way or other, supply energy to the system. On the other hand the second law of thermodynamics is a powerful tool for use in analysis of energy systems, including those in which living matter is involved.

The law of mass production. The law of mass production states that all living things tend to reproduce at such a rate that the population outstrips the food supply. The deer in some of our northern forests, for example, reproduce to the point at which they eat all available food, including the leaves of trees within reach of their outstretched mouths. When the food supply is reduced, as it is when the ground is covered with a blanket of snow, there is insufficient food for all the deer, and many of them die of starvation. However, unless a major calamity ensues which destroys almost all individuals of a species as happened in the case of the passenger pigeon, reproduction will continue at such a rate that again there will be an insufficient food supply.

This law of mass production apparently holds for all living things. Among plants there is a struggle for soil minerals, water and sunlight. Usually, the plant species that is best adapted to survive in a particular environment will be dominant in that environment Among insects there is a very high reproductive rate A large fraction of the insect eggs may not even hatch, but the number of eggs is usually so high that the small fraction that hatches usually leads to a total population of such a size that it has an inadequate food supply.

Children can see many evidences of this mass produc-ion in the environment The fluffy tuft of the dandelion contains hundreds of seeds from which new dandelion plants can sprout. Similarly, the female frog can discharge hundreds of eggs into a stream or pool which will become tadpoles and adult frogs. Trees produce thousands of seeds that are dis-persed in a variety of ways.

Teaching Science

As we work with children we must be concerned with both "how" we teach and "what" we teach It is useless to argue which is the more important - both are important. "What" children learn may be largely determined by "how" we teach. On the other hand, "how" we teach especially in science, should be determined by "what" we are teaching. The teacher endeavors to gain a profound understanding of the "what" and resourcefulness and skill in the 'how."

In science the "what" and the "how" of teaching are intimately intermingled. Perhaps our most important goal in working with children in science is to help them acquire a better understanding of the various approaches and methods of investigation that are used in the sciences. However, these understandings can probably only be developed through the demonstration of various approaches and use of the methods that are characteristic of the sciences. This is basically why our methods of teaching science must be consistent with the methods of sciences. Or, in other words, if we are to teach science effectively it must be taught scientifically.

Certainly, one of the best ways to teach science scien-tifically is to encourage children to identify significant ques-tions and problems in science and the work with them as they investigate these problems. Much of this work can take the

form of cooperative investigation in which pupils and teacher work together to clarify questions and solve problems. For example, in one classroom a child demonstrated that, when a large glass jar was placed over a burning candle, the candle eventually goes out. The child explained that there is a part of the air called oxygen that is necessary for the candle to burn. When much of this oxygen has been "used up", the candle can no longer burn. However, one of the children asked, "What would happen if the glass jar were raised so that some air could enter the bottom ? Would the candle go out? The teacher asked him to clarify what he meant by his question, and he placed the glass jar on two blocks so that air could enter the jar. Next, the teacher asked the class to predict what should happen to the burning candle under these conditions. In other words, she asked the children to use what they knew about gases and the nature of burning to form an hypothesis. They then went ahead, tried the experiment, and tested their hypothesis. After the experiment had been completed, the teacher called the children's attention to the various methods that they used to had investigate and try to answer a question. Through this cooperative investigation of a relatively simple, but important, question, the teacher demonstrated some of the characteristics of a scientific approach.

Our teaching of science should help children develop more sophisticated concepts of the broad generalizations of science. Through their invesigation of the burning candle under a glass jar, the children should have developed a clearer understanding of the nature of burning. For example, they can learn that only a fraction of the air is utilized in the burning of the candle. They can swish lime water, which becomes a milky colour when exposed to carbon dioxide, around in the jar and discover that carbon dioxide, that

was previously not present in very large amounts, was formed as a product of the process of burning. They can also discover that warm gases, in this case gases rich in carbon dioxide, tend to rise and cooler gases tend to descent. This is probably the principle reason that the candle will be extinguished even though the jar is raised so that fresh air could, but does not, enter through the neck of the jar. These are examples of important generalizations concerning the nature af burning and the behavior of gases. One of the important results of our teaching should be that our children gain a clearer concept of some of the major generalizations of science.

The effective elementary school teacher uses a variety of methods of teaching. Science as an area of teaching and learning is rich with opportunities to use a variety of approaches to teaching. Controlled experiments, research investigations, field trips, demonstrations, imaginative analogies, and a wide variety of audio-visual tools and materials are available for use in teaching of science. Throughout this book there are many concrete suggestions of a variety of ways to teach science.

Children experiment An experiment is a trial or test which serves to prove or disprove a statement. A child suggests an hypothesis or possible answer or possible solution for a problem. An experiment is devised to test whether or not the hypothesis is an adequate answer.

The most common form of experiment, and the one most often used in the elementary school, is the controlled experiment in which all factors but one are controlled. For example, one child asked, "What would happen if a plant is grown upside down?" The class suggested the hypothesis that the stem of the plant would gradually turn and begin growing upward again. The class obtained two gera-

nium plants and turned one of them upside down. However all other factors had to be controlled and the children made certain that both plants received the same kind and amount of water, light, fertilizer and were grown under the same general conditions. Any difference in the pattern of growth of the upside down plant would probably be due to the variable factor, i. e., because the plant was growing upside down. Children should have many experiences in science of trying to control all factors but one.

In a different form of experiment one factor is changed over a period of time. A group of children kept a record of the nature of conditions in an aquarium under the usual lighting conditions when the aquarium was kept on a shelf along the wall opposite the windows. In particular they noted the amount of algae that grew on the sides of the aquarium. Then, the aquarium was shifted to a shelf next to the windows where the aquarium was exposed to direct sunlight, and the amount of algae was noted. As usual, more algae grew when the aquarium was exposed to direct sunlight. In this case, the aquarium under the normal conditions was the control. The effect of changing one factor was studied by moving the aquarium to a site where there was more light.

Children Investigate An investigation is a search for information. The investigation may be primarily a search of the literature; in the elementary school this means a study of the children's science books and magazines to be found in the classroom or library. Or, it may mean an investigation of some area such as a corner of the school ground or the study of weather conditions over a period of time. An investigation is not necessarily designed to prove or disprove an hypothesis. Instead, it is designed to obtain more information about phenomena of interest to children.

A fourth grade class was studying the solar system

he teacher organized the class into a research seminar. mall groups of children choose to investigate the characteri- ics of each of the planets of the solar system. For example, ne group made an investigation of the planet Mars. With e help of the teacher and two of the parents, they listed a ries of questions about Mars such as: "What is the mperature on Mars?" "Is there water on Mars? "Could ere be living things on Mars?" The teacher and the hool librarian helped them to locate information about ars in magazines, encyclopedias and science books. All in , these children consulted thirty books and managed to ail themselves of the current information related to their estions concerning Mars.

Often, children can investigate phenomena directly. e group of children in the suburb of a large city wished find out whether weather conditions in their suburb ered from those in the nearby large city. The weather a for the city were available in the daily newspaper, but data were available concerning local weather conditions. refore, the children set up, on the school grounds a ll weather station' complete with thermometers, barometer, d vane, rain gauge, and humidograph. They kept a set cords for a school year and compared their records with e from the nearby city. Among their interesting findings the discovery that the average temperature at any given was a few degrees, 2-4 degrees, higher in the city than heir locality. In investigations of local phenomena, ren can obtain original data that may not be available here else.

Through investigations children can learn how to use esource materials available in science. They learn that e is a cooperative venture, and in other to obtain

answers to our questions we have to depend on the work of others. Through investigations children use the work of others to build their concepts concerning the world in which they live.

Sometimes, of course, they find conflicting views and information. and they have to learn how to evaluate various sources of information. From such studies they should develop criteria for the evaluation of information and sources of information. The fourth grade children in the example given, evaluated their information in terms of whether there was general agreement among the information sources, recency of the information and the qualifications of the authors of the articles and books. To learn how to evaluate conflicting sources of information and claims and counter-claims is certainly a desired outcome of elementary education.

The art of explanation. To explain is to describe, demonstrate or interpret ideas in such a way that they become clear to the learner and can be understood. One of the Primary functions of the teacher has always been that of the explainer. This is especially true in the teaching of science, where, the ideas we deal with are sometimes complicated and often far removed from the common, everyday experiences of children. The teacher has to help children achieve explanations for events that involve changes at the magnitude of the atom that have never been viewed by man. In science children also study stars and galaxies that are of such a magnitude that our ordinary earth-limited units of measurement are of little meaning. Fortunately, almost all children are keenly interested in the phenomena associated with the very, very small and the very, very large. However, these phenomena are a challenge to the teacher's imagination and skill in the art of explanation.

One of the most effective ways of explaining is through

e use of *demonstrations*. In the classic sense a demonstration ows how something works. For example, a teacher can monstrate how the rotation of the earth leads to day and ght by spinning a globe as it is exposed to light from distant source. One half of the globe will always be posed to light while the other half is in shadow. Such demonstration can be used to explain phenomena, such day and night, that children observe in their environment. is traditional form of demonstration of how something rks always be one of the most important tools in the enal of anyone teaching science.

The *Cooperative investigation* consists of a variety of periments that grow out of the questions of children or chers. For example, a teacher put a streak of water on chalkboard, and, of course, the water soon disappeared. What happend to the water ?" Many possible explanations the disappearance of the water were listed : "The water nt into the air." "The water went into the chalkboard." he water was absorbed by the chalk." The water just appeared." Each of these possible explanations were amined, and a series of simple experiments and demonstrans were set up to test them. Through a series of devemental demonstrations the teacher helped the children elop more sophisticated concepts of what happens when iquid such as water apparently "disappears."

Cooperative investigations require considerable plang and skill on the part of the teacher. The teacher should ticipate the questions that will be raised by the children order to have the necessary demonstration materials on nd. To do this, the teacher should have some knowledge the kinds of questions that can be asked about a phenona and sensitivity to the different kinds of questions that ividual children in the class are prone to ask. In coope-

rative investigation children often lead the teacher into new and exciting areas of science. Undoubtedly, the use of cooperative investigation leads to some of our best teaching of science.

The effective teacher also uses *analogies* to explain. In using analogies the teacher relates that which he is trying to explain to something that is fairly well known. "There are as many stars in the heavens as there are grains of sand on the beach." Strictly speaking, there is no way to determine whether this analogy is true, but it is a way conveying to children the idea that there is a tremendously large number of stars in the universe. Similarly, an analogy, between the nature of the framework of a building and the nature of science was used in an attempt to explain some of the characteristics of science. Obviously, but it is hoped that the analogy helped to explain and make clear a complicated series of ideas.

Analogies are useful tools for explanation, but they must not be used as proof. This is a common mistake in logic often committed by both children and adults. To say that, "Electricity flows through an electrical circuit somewhat like water flows through pipes, "does not prove anything. It is an analogy used to explain but cannot be used as evidence or proof.

The good teacher of children use a wide variety of approaches and a rich assortment of methods in teaching. Probably, a greater variety of approaches and methods can be used in science than in any other subject in the elementary school curriculum. Children can become involved in experimentation, demonstrations, field trips, projects and research. The teacher can use books, charts, films, film-strips, models, diagrams, analogies and television programmes

to help children get a better understanding of the scientific methods of investigation and the major generalizations of science. The use of a wide variety of approaches and materials in teaching is certainly consistent with the nature of science.

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Planning Science Instruction

J. K. Sood

In the words of Nathan S. Washton, 'The artistry of teaching is dependent on how skillfully the teacher blends several of the methods into a unified teaching lesson. The nature of the lesson, the personality and goals of the teacher, the climate of the class, and the interests and needs of the students will determine the ultimate selection and utilization of appropriate teaching methods in science' (i).

This clearly indicates that good teaching includes the proper selection of content, formulation of objectives, organising learning activities, based on careful planning. The last factor, namely, careful planning is very important for the new entrant in the profession of teaching, which will build confidence in him. Here, we will discuss 'Unit', Lesson' planning.

Unit Planning

Unit Planning is an innovation of this century. *First* of all Morrison attempted on its definition in 1926. Since then many adjectives have been added to this term, unit, i.e. subject matter unit, topic unit, experience unit etc In 1945 Smith further classified these units, such as :

1. *Process Units* : Units of discovery and verification.
2. *Normative Units* : Units establishing policies.
3. *Critical Units* : Units establishing critical skills and abilities.

In 1952 Burton clarified that all aforesaid parts are used in all units with different emphases.

hat is a Unit Planning ?

The term 'unit' signifies the 'unity' or 'wholeness' the learning activities related to some problem or topic. lanning' involves the selection of the proper, suitable paths om the alternative ones.

Therefore, 'unit planning' is the proper selection of rning activities which are closely related with each other d present a complete picture. In other words the aching unit, is neither a block of subject matter nor a ies of independent lessons (2). For example in Physics, at, electricity, magnetism are a few examples of block of bject matter In Biology chordates, non-chordates, fungi are amples of block of subject matter. In Chemistry metallurgy etals, non-metals are the examples of block of subject atter. Similarly the examples of independent lessons in fferent subjects are as follows :

ysics : (a) What is electricity ?
(b) Use of magnets.

ology : (a) Difference between plants and animals.
(b Chemistry of digestion.

emistry: (a) Preparation of oxygen
(b) Properties of NH_3 gas.

Unit should be a big gestalt of teaching-learning uations Many authors agree that it should not include ore than seven lessons, and not less than two lessons, which e interrelated and interdependent, with suitable scope and quence.

Some examples from different disciplines of science e given below .

Physics : *Unit*–Transmission of Heat

Lessons : (a) Conduction

(b) Convection and Radiation.

2. *Biology* : *Unit*–Nutrition in human beings.

Lessons : (a) Organs helping in Nutrition.

(b) Chemistry of Nutrition.

3. *Chemistry* : *Unit*–Acids, Bases, Salts.

Lessons : (a) Acids.

(b) Bases and salts.

Units should be developed in a logical sequence. Th teacher should not adhere to rigidity and should keep fait in flexibility.

What to Include in a Unit

While planning teaching units the teacher shoul include such activities that are based upon student interest and needs. What a teacher should write in unit planning i always a matter of discussion. Yet to get a common poin of view we can include the following :

1. Overview
2. Objectives
3. *Learning situations :*
   (a) Initiating activities
   (b) Learning activities
   (c) Culminating activities
4. Evaluation
5. References.

1. Overview

The purpose of overview is to describe the nature and scope of the unit *It should not cover more than two* paragraphs.

2. Objectives

It should include :

(a) Basic Science Information

Desirable behaviour change.

Basic science information includes scientific facts, [un]standings, generalizations, principles, laws, concepts [and c]onceptual schemes.

Desirable behaviour includes abilities, skills (both [ment]al and manual), scientific—attitude, appreciation, [intere]sts etc.

[Le]arning Situations

Initiating Activities

It is to involve the child in learning. It develops [curio]sity and interest. This can be initiated :

1. By questioning
2. By raising problems
3. By developing relation with previous unit.
4. By giving a thought provoking experiment or demonstration
5. By thought provoking discussion
6. By the use of film or filmstrips.

Learning Activities

These are the means by which basic science informa[tio]n is learned and desirable behaviour in the child is [dev]eloped.

) Culminating Activities

These activities conclude the unit.

Evaluation

Proper methods of evaluation should be used for [ju]dging the behavioural change in the child.

References

Proper references should be included.

Advantages of Unit Planning

1. It helps in the selection of new activities/experiences class-room use.
2. *It keeps enough margin for flexibility.*
3. Unit *planning helps in anticipating the future problem*
4. Topics of the Unit should be related (as for as possibl either with community or *specific Key ideas* / big id rather than simple topics or headings For exam 'water supply' should be 'a study of our water sup system', 'Electricity' should be 'electricity in homes'.
5. *Unit planning extends student experiences* beyond t unit of the prescribed syllabus.
6. It develops coherence among different lessons.

Proforma for Unit planning

I Subject — Class
Unit — Duration

1. Overview
2. Objectives
3. Learning Situations — Initiating activities, Learning activities, Culminating activities
4. Evaluation
5. Reference

II	Subject	Class
	Unit	Duration

Lesson/Topic	Objectives	Learning Situations	Evaluation

References

The Daily Lesson Plan

The science teacher has abundance of things which he can use for classroom teaching. Proper selection of the material and the use of various procedures, to be employed in the classroom, necessitate daily planning. Consequently, the daily plan becomes an essential part of classroom teaching. Rarely, a teacher gets a chance to prepare an independent lesson. Generally, a lesson is developed in relation to other lessons or as a part of unit.

What is a Lesson Plan ?

The term lesson is interpreted in different ways by different people. Generally, teachers take it as a work to be covered in a class period which runs over 40-50 minutes or in two to three periods. Others difine lesson as a *blue print, a guide map, a plan or guide for action in the near future; a creative piece of work; a comprehensive chart for classroom teaching; a systematic, elastic approach for the development of concepts, skills, understandings etc.* Thus in general lesson plan is a guide for action which will help the teacher in presenting learning experiences

Uses of Daily Lesson Plans

(a) Planning provides direction to the task undertaken. Therefore, a lesson plan gives direction to the teacher and students for teaching and learning.

(b) While planning it becomes easier to select proper, adequate subject matter, needed for particular age group.

(c) The subject material can be easily organized in a proper and functional way which will help in achieving the instructional objectives of science education.

(d) Planning helps in developing a relationship between learning activities and the time it requires. Thus economy of time can be achieved.

(e) It provides an opportunity to the teacher to use his new ideas, imaginations. He/she can give a practical shape to these ideas.

(f) Planning gives an idea about the difficulties a teacher can face during his teaching programme. Therefore, all difficulties can be anticipated while planning a lesson and their solutions can be incorporated at the planning stage.

(g) Lesson plan develops confidence in the teacher and brings refinement in the art of teaching.

(h) It eliminates the chance of trial and error in teaching.

(i) Lesson planning helps the teacher in visualising the needs of students. Students vary in abilities and interest. An effective teacher attempts to plan for these variations also.

Factors Affecting Lesson Planning

There is no gurantee that a lesson plan developed by a teacher for his/her use, will be a success at every place and any time. Reason is simple. Many factors influence lesson planning and the success of its presentation depends on them. These factors are:

1. The school : urban or rural.
2. Number of children in the class.
3. Average age of students.
4. Standard of attainment.
5. Children's knowledge assumed by the teacher.

6. Availability of teaching aids.

7. Aims of the lesson.

8. Personality and philosophy of the teacher.

Therefore, all these factors should be taken into consideration while planning for daily teaching. Lesson planning changes as the factors or situations change. A lesson plan prepared by a teacher is meant for him and his class.

Writing the Plans

A teacher needs some information about the class, students, and their background before he/she attempts to plan a lesson or unit. Generally a lesson is divided into many stages or steps When a detail lesson plan is being developed all these steps are used in some form or the other. But in a brief plan many steps/stages are integrated with one another. There steps/stages do not classify any psychological principles nor are based on learning theories. They appear to be based on common sense and give a logical order to the plan. These steps are :

1. General information

(a) Subject.

(b) Unit.

(c) Lesson/topic.

(d) Class

(e) Age level of children.

(f) Estimated time.

(g) Date.

2 Instructional objectives as learning outcomes

(a) General

(b) Specific

In writing objectives for a lesson, careful thought should be given to state the instructional objectives as general learning outcomes. These should focus on the expected outcomes of instruction. A detail description of outcomes of science education is given in this book (p p. 17–30) which gives some idea, about their specifications also. These specifications should reflect terminal behaviour of the student and should be written in such specific terms which can be observed or measured. In writing objectives one should provide clarity, appropriateness, adequacy and attainability. These objectives should have definite relationship to evaluation of students learning

3 Instructional Aids

Proper selection and effective use of teaching aids motivate students and clarify the concepts of science. Aids should be used skillfully and at the right time. These may range from simple diagram to films. Their utility depends on proper handling.

4. Previous knowledge assumed by the Teacher

Development of the lesson is based on the previous knowledge of students. This knowledge serves as a base for further learning. Therefore relevant assumption by the teacher is a necessity for saving the wastage of time.

5. Procedure/Method

A variety of methods are used by teachers for teaching. In a lesson plan a brief mention of procedure gives an idea

about the approach as well as of activities which a teacher will undertake to complete the lesson. While planning a brief lesson plan, procedure can present a vivid picture of the whole lesson.

6 *Introduction (of the lesson)*

Introduction is a very crucial point in teaching and planning. It shall help in

(a) reviewing the previous knowledge of students.

(b) providing enough opportunity to motivate students, and

(c) introducing the new knowledge. When a new lesson is being introduced, the teacher should try to stimulate and generate pupils interest in the topic. A lesson can be introduced by the help of an *effective teaching aid or actual material.*

7. Development of the lesson

This comprises all teaching learning situations which involves :

(a) Content.

(b) Method (including audio visual aids)

(c) knowledge about the development of children.

Content is a base for the learning activities based on concepts and processes of science and methodology helps in proper arrangement of the content. Content should be selected carefully in terms of the instructional outcomes. It should be accurate, relevant and rich enough in its depth. It should reflect the contemporary knowledge

The use of methods or synthesis of methods depends on the content and philosophy of the teacher. In science

teaching, experimental approach; investigatory approach or problem solving approach is generally used. It depends on the resourcefulness and ingenuity of the science teacher.

Just motivation for learning is not sufficient in teaching. Continuous interest should be maintained in the whole period. Generally, a lesson is not based on a specific theory of how children learn or on the logical structure of science. (It is a neglected aspect in most of the cases.) Thus, many times a lesson is psychologically unsound. Use of concerte things and active participation of children in learning, are supported by Piaget's great ideas on intellectual development. Hence, we should try to base our lesson on activities as far as possible.

8. Recapitulation/Evaluation

Recapitulation helps the teacher to find out to what extent learning occured during that period. It can be done by asking several questions or by arranging oral situations or written stuations.

9. Black board Summary

Activities during recapitulation gives a gist of black-board summary. Or it can be developed simultaneously when lesson is being developed.

10. Home Assignments

Proper assignments gives a chance of repetition to students or solving similar problems in new situations.

11 References for self and students

It helps the teacher in incorporating proper reference materials and give an opportunity to locate proper books.

12. Self Evaluation

After the completion of teaching, a teacher should try to see that how far he was successful and improvements he needs for future.

mary and self Evaluation Check List

In unit/lesson planning careful selection of content, ction of appropriate method and resourcefulness of the cher will help in the development of pupil growth in the s of reflective thinking and attitudes. At planning e many ideas presented in the preceeding pages can be rperated but it is difficult to present any ideal lesson ch will be useful for all and for all times. It is also easy to present an ideal format for a unit as well as on planning. Main purpose of lesson planing is to present tive learning experiences. Each lesson presents a part he unit. And all lessons present a whole unit both in dth and depth. Before planning a lesson and after ompletion a teacher can use a check list for his own tinuous professional growth.

ck list

Self Evaluation of unit/lesson

	yes	no	Remarks
nstructional objectives			
. Are the objectives related to the subject matter?			
. Are the objectives adequate?			
. Are the objectives specific?			
. Are the objectives written in the terms of behavioural outcomes?			
5. Are the objectives appropriate?			
6. Are the objectives attainable?			
. Content and Teaching Aids			
7. Is content adequate?			
8. Is content relevant to the topic?			
9. Is content suitable for the age group for which it is meant?			
10. Is content accurate?			

	yes	no	Remarks
1. Is the organization of content psychologically sound ?			
2. Are the learning activities adequete?			
3. Is there full involvement of children?			
4. *Is there provision of variety in* learning activities ?			
5. Are learning activities effective ?			
6. Are teaching aids appropriate ?			
7. Is there any innovation in these teaching aids ?			
I. Methods and Evaluation			
8. *Is this method effective ?*			
9. Is there any originality in this method ?			
). Is this method appropriate for children ?			
1. Is the tool suitable ?			
?. Is the tool comprehensive ?			
. Is there continuity in evaluation ?			
. Is evaluation relevant to the objectives ?			
. Is evaluation appropriate ?			

ferences

1. Washton, Nathan S. Science Teaching in Secondary Schools. New York : Harper and Row, 1961

2. Kenneth, Hoover H, Learning and Teaching in the Secondary Schools. Boston : Allyn and Bacon, Inc, 1964.

3. Viadya, N. Sood, J. K. Planning for Science Teaching. Ajmer : Regional College of Education, 1968.

Suggested Readings

1. Voss, Burton E., Brown, Stanley W. Biology as Inquiry. A Book of Methods. Saint Louis : The C. V. Mosby Company, 1968.

2. Gronlund, Norman E. Stating Behavioural objectives for classroom Instruction. London ; the Macmillan Company, 1970.

3. Andrews, Dale W., Juergenson, Elwood M. Selected Lessons for Teaching Agricultural Science. Illinois ; The Interstate Printers and Publishers, Inc., 1961.

Some Sample Unit and Lesson Plans

A few sample unit and lesson plans are given here. hey illustrate many ideas discussed in the preceeding pages. t the same time many illustrative lesson plans present ifferent philosophy. Intentionally this variety is given that a reader may get a glimpse of different lesson plans hich are in use in this country. The following plans are scussed in the order given below :

nit plan (1) Behaviour of Gases.

sson Plan (1) Ionization

(2) Archimede's Priniciple

(3) *Germination of castor seed*

(4) Leaves

(5) A case History for the Teaching of General science.

(6) Hard and soft water.

(7) Burning.

Unit Plan

S. B. Singh
A. K. Mandal
H. N. Subanna
D. D. Sharma
L D J Padh

Subject : Physics *Unit* : Behaviour of gases *Class* IX

Major objectives of the unit :

1. To help pupils to understand the behaviour of gases (in general)
2. To develop the skills of observation, experimentation, and preparing improvised apparatus to study the behaviour of gases
3. To stimulate pupils interest in the study of the behaviour of gases.
4. To develop investigatory approach of doing things

S. No.	Major Concepts	No. of lessons	Time required	Scope of the content
1	Gases occupy all the space available to them.	one	40 minutes	Experimental verification of the behaviour of gases
2	Gases move about readily and one gas even penetrates through the other.			To study the following with respect to gases (a) Motion of Molecules in gases. (b) Influence of volume. (c) Influence of pressure. (d) Influence of temperature.
3	Gases are easily compressed	one	40 minutes	
4	Gases have the property of diffusion			
5	Molecules of a gas have Brownian motion	one	40 minutes	
6	Gases exert pressure on the walls of the container			

S. No.	Major Concepts	No. of lessons	Time required	Scope of the content
7	If the temperature remains constant the pressure of a fixed mass of a gas varies inversely as its volume (Boyle's law)	one	40 minutes	
8	The volume of a gas increases with the increase in temperature	one	40 minutes	

Presentation

S. No.	Content	Objectives with specification	Teacher-pupil objectives	Learning aids or Teaching aids
1	Gases occupy all the space available to them.	Knowledge The pupil recalls and recognises the process used in daily life and laboratory.	The teacher recalls the Lavender bottle open in one corner of the room or a scent bottle	Lavender bottle or a Scent bottle
2	Gases move about readily and one gas even penetrates through the other.		The teacher conducts the experiment to show the property (a) N_2 and O_2 gas jars are held one above the other. (b) Smoke jar and a jar containing air are held one above the other.	Gas collecting Jars containing. (a) Nitrogen (b) Oxygen (c) Air (d) Smoke
3	Gases are easily compressed.		The teacher encourages the pupils to blow a baloon and study the possibility to.	Baloon and air pump.

S. No.	Content	Objectives with specification	Teacher-pupil activities	Learning aids or Teaching aids
			compression.	
4	Gases have the property of diffusion.		Diffusion : Fill in a baloon with ammonia gas and put it in water containing phenopthalein. The solution turns milky.	A baloon filled with ammonia water and phenopthalein.
5	Molecules of a gas have Brownian motion.	Application Applies the knowledge while studying gases collecting gases, mixing gases and observing gases etc.	The teacher gives an example of the movement of dust particles *in a beam of light.* The teacher also demonstrates the principle with wooden tray and marble.	Wooden tray, pieces of small marbles and two or three big marbles
6	Gases exert pressure on the walls of the container.		Pupils conduct the experiment to lift the book, kept on a bladder by blowing air into the bladder.	A foot-ball-bladder, a book and an air pump.

S. No.	Content	Objectives with specification	Teacher-pupil activities	Learning aids or Teaching aids
7	Temperature remaining constant, the pressure of a fixed mass of a gas varies inversely as its volume.	Skills : (a) Draws neat and proportionate diagram. (b) Arranges and handles the apparatus. (c) Takes necessary precautions. (d) Devices experiment to study the behaviour of the gases.	An experiment : Additional books are placed *on the platform*. The air in to the cylinder is compressed and the height of the air column becomes less. The no. of books used serve as a measure of pressure and the weight of the air column gauges the volume.	Apparatus to demonstrate the Boyle's law.
8	The volume of a gas increases with the increase in temperature.		A tincan fitted with a rubber baloon to its mouth. First dipped in boiling water and then dippend in cold water. Pupils observe and draw the inference.	Tincan, a rubber ballon, two big beakers, one containing boiling water and other containing water at the room temperature.

Evaluation :

I. 1. How do you show that gases are easy to compress and change in shape ?
2. Describe an experiment to show the volume of a gas can be changed.
3. Gases expand when heated and contract when cooled-explain with a suitable experiment
4. How do you explain the space between molecules in a gas ?
5. List out the influence of pressure, volume and temperature in a gas.

II. Give scientific reasons for the following :
1. During summer cycle-tube bursts are more frequent.
2. As the gas filled baloons raise high in the air, its volume increases and ultimately bursts at a certain height
3. Why it is advisable to carry ball-point pens instead of foundtain pens for high altitude air travellers?
4. It is better to cool the liquid ammonia bottle before opening
5. How do most odours reach you ?
6. What happens to air when you move around ?

Books for Ready Reference

1. P. S. S. C Text Book (Chapter IX).
2. Science Teaching by Thurber and Collette.
3. Chem Study, the experimental science (NCERT)
4. The Teaching of Science by G. S. Das.
5. Source book for Science Teaching-UNESCO.
6. P.S.S.C. Film on Behaviour of gases.

Lesson No. 1

M. K Gupta

Sub Chemistry *Unit* : Ionization

Topic Electrolysis of postassium iodide

Objectives

After the lesson is over, students shall be able to :

(a) describe the result of electrolysis of KI; Potassium and Iodine are formed

(b) postassium reacts in solution with water and potassium hydroxide and hydrogen.

(c) I_2 is liberated at anode and identified by blue colour with starch.

(d) suggest the possible mechanism of the reaction.

Materials

U-tubes, beakers, 2 volt batteries, carbon electrodes, distilled water, potassium iodide solution, connecting wires, crocodile clips etc.

Procedure It shall include :

Instructions by teacher to the pupils;

Activities of the pupils;

Group discussions among themselves;

Report of all the groups;

Discussion of the mechanism;

Evaluating the pupil's learning by administering a questionnaire.

1. **Instructions by the teacher to the pupils**

(i) Arrange the apparatus for the electr
sium iodide using carbon electrodes e
or U-tubes or big glass tubes as sh
gram. Care is to be taken that n
over the clothes.

(ii) Check all electric connections.

(iii) Electrodes must dip inside the solut

(iv) Recall about the experiment on
water, collection of its product an
on the basis of some chemical p

(v) If one of the product is gas then
collection.

(vi) If you feel that some chemicals are
identification of the product of the r
collect from the common shelf and
it to the shelf.

2. **Activities of the Pupils**

Take 25-30 ml. of potassium iodid
assemble apparatus as required and start ele
for 5 minutes and note the changes in the so

3. **Group discussions among themselves**

(i) Elect, one reporter from all the
group.

(ii) Discuss the probable mechanism
the evidences and experime
that have made.

(iii) As far as possible give the reaso
nation of a mechanism you hav

4. **Report of all the groups**

Common points relevant to the topic
rized by the teacher.

5. Discussion of the mechanism

Mechanism of the reaction shall be discussed in detail involving the pupils using their experiences and explanations derived from experiments.

6. Evaluating the pupil's learning through distribution of a questionnaire Scoring Board.

   Tick mark the correct answer (✓)

   1. Potassium iodide solution contains (atoms of potassium and iodine/ions)
   2. When solution is diluted number of (atoms/ions) increases.
   3. Particles which are attracted by the cathode are known as (cations/anions.)
   4. Process of producing the ions from the salt molecule in water is known as (electrolysis dissociation/ ionization.)
   5. Particles coming in contact with the elctrode after completing of circuits are converted into (charge particles/neutral particles)
   6. The product of the reaction are identified in the (charged form/neutral form.)
   7. Number of negative and positive particles in the solution remain (equal/unequal)
   8. Starch gives the identification for (iodine/molecule/ ion.)
   9. The drops of phenopthalein are utilised for identification of (Hydroxide ions/potassium ions.)
   10. One of the gaseous product in your reaction is (oxygen/hydrogen/Iodine.)

Assignments to be carried out in the laboratory

1. Take solution of potassium iodide of different

concentration. Repeat the experiment as above. Note the timings for the appearance of the colours at anode as well as at cathode.

2. Repeat the same experiment as above but introduce a torch bulb between the circuit and note the intensity of light in the bulb with all the concetrations of potassium iodide. If possible give reasons for the observed facts.

4. Repeat the experiment as above in No. 1 but with a different voltage of the battery and find out the possible reasons for the observed facts.

ading assignment

1. Chapter on Ionization (Physical Chemistry by Bahl & Tuli.)
2. Chapter on Electrolvsis of potassium iodide (Chem-Study text.)
3. Chapter IV–Electricity and matter (Chemical Systems.)

Lesson No. 2

S. B. Singh
G. N. Bhardwaj
A. K. Mandal
Sovanna
Laxmi Das J Padh
D. D. Sharma

Subject Physics

Topic · Archimedes' principle

Time : 45 minutes

Objectives

(1) The pupil will acquire knowledge of facts such as

(a) Every liquid exerts on the body immersed in it a buoyant force directed vertically upwards.

(b) The value of the buoyant force depends on the volume of the body.

(c) Heavier the liquid, greater is its buoyant force.

(d) The apparent loss in the weight of the body is equal to the weight of the liquid displaced by it.

(2) The pupil will use the available data to arrive at some conclusion (generalisation)

(3) The pupil will show a keen sense of observation in taking reading etc.

Previous knowledge

(1) All bodies seem to lose weight when immersed in liquid.

(2) The pressure at a point in a fluid is the same in all directions.

(3) The pressure at the bottom of a liquid column of height h=hdg, where d = density of the liquid and g = acceleration due to gravity.

(4) Force=Pressure x Area

Procedure

The topic will be introduced by discussing some of the common observations made by students in every day life. Then by using demonstration method the teacher will help the students to discover the qualitative relationship between the loss of weight of the body and the weight of the liquid displaced. Quite often the teacher will ask searching questions to judge the results of his efforts. The students will generalise on the basis of the observations made by them (inductive method.)

Teaching aids

Two spring balances, one physical balance, graduated cylinder, 3 beakers, water, kerosine oil, glycerine, solids some heavier and other lighter than water.)

Teaching points/ specific objectives.	Teacher's activity	Student's activity
To test the Previous knowledge and to introduce the topic.	Suppose we attach a half Kg. weight to the hook of spring balance and then immerse it in water. Will the pointer remain at the $\frac{1}{2}$ kg. mark or it will indicate less or more weight? (if needed this will be actually demonstrated.)	It will indicate less weight.
	If we immerse a cork under water and release it. What will you observe ?	It will come floating to the surface.
	We may easily lift a body while it is under water but we may find some difficulty in lifting it on the ground. Why so ?	A body seems lighter in a liquid or the liquid exerts buoyant force on the body.
	How can you explain the decrease in weight of a body when it is immersed in liquid ? What does the value of the buoyant force depend on ?	Students are not expected to give proper answers of these questions.
	Statement of the aim : To day we will try to find out the answers to these questions. Many years ago Greek Scientist named Archi-	

Teaching points/ specific objectives.	Teacher's activity	Student's activity
	medes (287–212) B.C. did similar experiments and he discovered a very important law of nature which is now called Archimedes' Principle (Story about the Crown of King Hiro of Syracuse, Sicily may be narrated)	
Every liquid exerts on the body immersed in it buoyant force directed vertically upward.	A cylinder is attached to the hook of a spring balance and one student is asked to note the position of the pointer. Then the cylinder is immersed in water and the student is again asked to note the positions of the pointer.	Students note.— (1) Reading of spring balance when cylinder is in air = a gms. (2) Reading of spring balance when cylinder is immersed in water = b gms.
	Q. Why does the spring contract when the cylinder is immersed in water ?	An upward buoyant force acts on it.
	(However if the students are unable to give a proper reply the teacher will ask the following question :— Keeping the cylinder still in air what should we do to	

Teaching points/ specific objectives.	Teacher's activity	Student's activity
	bring the pointer from original extend position to the contracted position ?	
	(Using demonstration, necessary, the students will be made to realise that an upward force should be applied. When the cylinder is immersed in water this upward force is supplied by the liquid.)	
The value of the buoyant force depends on the volume of the body immersed in the liquid and it is greater if the greater is the volume of the body.	A cylinder is attached to the spring and lowered into water. One student is asked to report the initial and final readings of the balance and also to note the increase in level of the liquid when the cylinder is immersed in it. The experiment is repeated with an equal weight but whose volume is different from the volume of the cylinder.	The students note down the reading.

The observations are tabulated on the Chalk board.

Body	Weight in		Level of water		Loss of weight in liquid	Volume of liquid displaced
	Air	Water	Initial	Final		
	x	y	P	Q	X-Y	P-Q
1						
2						

Q. Which body seems to loose more weight when immersed in water the one whose volume is greater or the other whose volume is less ?

The body whose volume is more loses more weight.

Q. Now tell me whether the upthrust depends on mass or on volume.

The upthrust depends on the volume of the body.

Bigger the specific gravity of the liquid greater is its buoyant force.

A cylinder is first weighed in air and then in serveral liquids. The students are required to find the loss of weight in each case

Weight of the cylinder in			
Air	Water	Kerosine oil	Glycerine
a	b	c	d

Loss of weight in		
Water	Kerosine Oil	Glycerine

	Q. Which is the heaviest liquid ?	Glycerine
	Q. Which is the lightest liquid ?	Kerosine oil
	Q. In which liquid the loss of weight is greatest ?	In the case of glycerine
	Q. In which liquid the loss of weight is the least ?	In Kerosine oil
The apparent loss of weight is equal to the weight of the liquid displaced.	The students are required to observe that there is a cylinder which exactly fits in a bucket i. e. the volume of the cylinder is equal to the capacity of the bucket and the cylinder is attached to the spring and the position of the pointer is noted. The cylinder is immersed in water and the position of the pointer is again noted. The bucket is now gradually filled with water and it is seen that the pointer returns to the original position when the bucket is full.	Volume of cylinder =Capacity of bucket
	Q. What do you observe regarding the relationship between the loss of weight in water and the weight of the water filled in the bucket ?	They are equal.

Q. What is the relationship between the weight of water in the bucket and the weight of the water displaced by the cylinder ?	They are also equal.
Q. What do you conclude regarding the relationship between the loss of weight in water and the weight of water displaced by the cylinder ?	Loss of weight—Weight of water displaced.
The experiment is repeated with another liquid say glycerine.	The students observe the same relationship here also.
Q. What general law governs the relationship between the loss of weight and the weight of the liquid displaced ?	In each case the weight of the liquid displaced is equal to the loss in weight of body.

A buoyant force acting upward appears due to the different pressures exerted upon the upper and lower surfaces on the body immersed in [illegible]

(The students will be told that the upper and lower surfaces of the body are at a depth h_1 and $(h_1 + h)$

Q. What will be the the total pressure at the upper surface ?	It will be $p + h_1\,dg$ (p = atm. pressure)
Q. What will be the total force acting on the upper surface, if the surface area is a ?	Total force $= a(p + h_1 dg)$
Q. What will be the direction of this force ?	It will act vertically downward.
Q. What will be the pressure at the lower surface ?	It will be $P + (h_1 + h)dg$
Q. What will be the total force on the lower surface ?	Total force $+ a[P + (h_1 + h)dg]$
Q. What will be the direction of this force ?	It will be vertically upward.
Q. On which suface the force is greater ?	It is greater on the lower surface.
Q. What will be the resultant force on the body ?	It will be $a[P + (h_1 + h)dg] - a[P + h_1 dg] = a h\,dg$

The body immersed in the liquid experiences pressure from all sides.

Q. What is the relationship between the pressure exerted at a point in a liquid depth of that point ?	The · pressure depends upon the depth.
Q. Suppose we take two points x and x' at the same depth but on opposite sides of the body. If the pressure at x is p, what will be the pressure at x' ?	It will also be equal to p.
Q. What about their directions ?	They will be oppositively directed.
Q. What will be the net effect of these pressures on the body ?	There will be no effect on the body as the pressures cancel each other.
Q. Similarly if we consider two points x, and at some other depth, what about the pressures ?	Pressures will again be equal be opposite in direction.
Q. What do you conclude regarding the net fore in the horizontal direction ?	It will be zero.

Q. What does the product of a (area) and *h*(height) depict ?	It denotes the volume of the liquid displaced.
Q. So what is the net force on the body ?	It is equal to V dg.
Q. What does the product of volume and density indicate ?	It indicates the mass of the liquid.
Q. What is the product of mass and g equal to ?	It is equal to the weight of the liquid.
Q. What is the total upward force acting on the body ?	It is equal to the weight of the liquid displaced by the body.

Recapitulation—Why do objects seem to loss weight when they are immersed in a liquid ?
On what factors does the buoyant force depend ?
What is the actual cause of the loss in weight when solids are immersed in a liquid ?

Assignments—Design an experiment to show that a liquid exerts a buoyant force on another liquid.

A spring balance indicates the weight of a body in air equal to 500 gms. and its weight in water equal to 400 gms. If 1 cc of water weights 1 grm. what is the volume of the body ?

Lesson No. 3

Marjorie H. Gardner

Subject : GENERAL SCIENCE

Standard IX | *Topic* : Germination of a castor seed | *Time* : 45 Minutes

(Assignment-discussion approach)

Content objectives :
1. Development of the concept of different stages in the germination of castor seed.
2. Knowledge of the terms: Epigeal and Hypogeal germination.

Process objectives :
1. To make observations
2. To identify the change
3. To record observations
4. To compare the data
5. To interpret the data
6. To develop skill in drawing figures.

Previous knowledge : Pupils have studied the structure of Maize, Bean and Castor seeds and the germination of Maize and Bean seeds.

Content	Specifications	Teaching learning activities	Evaluation
		Home Activity	
		Each pupil was given some castor seeds and was asked to germinate them a week before. He was asked to observe the changes daily. (Separate instructions regarding the procedure were issued)	
		Recording the data	
	Process Obj. 1, 2, 3	Pupils have observed the growth and made a record of them daily observations.	The work will be evaluated
		Class room activity	
1. When water enters through micropyle the seed swells and testa breaks.	Process obj. 1, 3, 5	Pupils will be asked to present their observations regarding the changes they have noticed in a tabular form. They will compare the data and arrive at	1. Which system is developed by radical ? 2. Which part of

Content	Specifications	Teaching learning activities	Evaluation
		certain conclusions.	a seed forms shoot system?
2. The radical comes out and grows downward. 3. Plumule comes out and grows up. 4. Plumule forms a loop. 5. When the plumule becomes straight the cotyledones are lifted up. 6. The radical forms the root system and the plumule shoot system. 7. Thin cotyledones turns green, forming leaf like structure.			
In maize and bean the	Process obl	The teacher will ask the pupils to compare	What [illegible]

Content	Specifications	Teaching learning activities	Evaluation
		Home Activity	
		Each pupil was given some castor seeds and was asked to germinate them a week before. He was asked to observe the changes daily. (Separate instructions regarding the procedure were issued)	
		Recording the data	
	Process Obj. 1, 2, 3	Pupils have observed the growth and made a record of them daily observations.	The work will be evaluated
		Class room activity	
1. When water enters through micropyle the seed swells and testa breaks.	Process obj. 1, 3, 5	Pupils will be asked to present their observations regarding the changes they have noticed in a tabular form. They will compare the data and arrive at	1. Which system is developed by radical ? 2. Which part of

Content	Specifications	Teaching learning activities	Evaluation
2. The radical comes out and grows downward. 3. Plumule comes out and grows up. 4. Plumule forms a loop. 5. When the plumule becomes straight the cotyledones are lifted up. 6. The radical forms the root system and the plumule shoot system. 7. Thin cotyledones turns green, forming leaf like structure.		certain conclusions.	a seed forms shoot system?
8. In maize and bean the	Process obj	The teacher will ask the pupils to compare	What major diff.

Content	Specifications	Teaching learning activities	Evaluation
soil. This type of germination is called Hypogeal. In the castor seeds cotyledones comes up with the plumule, hence the germination is said to be epigeal.		stage of the germination of Bean and Castor seeds. They will be asked to infer and suggest suitable terms for the new concepts.	notice in the germination of a Bean and a castor seed ?
	Process obj. 6	The pupils will be asked to draw *figures* showing different stages of germination in castor seed.	Pupils label the figures

Assignment : Observe the different stages of germination in the following seeds. Compare and draw conclusions regarding the type of germination.

1. Gram 2. Ground nut 3. Tamrind 4. Mango

Lesson Plan No. 4

(Investigatory approach)

Marjorie H. Gardner

Subject : General Science

Unit : Leaves.

Topic : Do plants give out water ?

Purpose : To train pupils to investigate problem.

Content objectives : Concept : Plants give out water.

Process objectives :

1. Locates problem
2. Formulates hypotheses
3. Tests hypotheses
4. Conducts simple experiments
5. Suggests appliances
6. Generalises

Previous knowledge : Roots take minerals in liquid forms and not in solid forms.

Aids and appliances : 7 sets of the following

(i) glass tumblers—2

(ii) Card board piece 4" × 4"—1

(iii) Water

Content	Specification of objectives	Teaching Learning Activity	Evaluation
Do plants give out water ?	Locates problem	Discussion In what form does root take minerals from soil ? Can it take in solid form ? Do you use all the water you drink ? What happens to it ?	
Hypothesis : 1. Plants do not give out water; we do not see it.	Formulates hypotheses.	Discussion-suggests answers.	
2. Plants may give out water.	Analyses, selects a probable hypothesis..	Discussion on the hypothesis.	
	Suggests a testing method.	Pupils discuss a method for testing the hypothesis.	

Content	Specification of objectives	Teaching Learning Activity	Evaluation
	Suggests appliances.	Discusses the appliances to be used for experiments. (teacher suggests improvements when only needed).	
	Suggests procedure and caution. Experiments, observes records.	Experimentation-Discuss procedure and caution. Work in 6 groups, observe, record.	How do you set the apparatus ? Describe the procedure. What are the cautions ?
Plants give out water.	Compares Generalises.	Post-experiment-discussion. The groups present their observations for comparison.	Do plants give out water.

Assignment—(1) Write down the experiment you have performed under the following titles—
Purpose, appliances, procedure, cautions, observations, inference.
(2) Repeat the experiment with twig with no leaves.
(3) Arrange two experiments as in (1), keep one in your room and the other in Sun. Observe, record your observation.

(to be entered after the [illegible])

A Case History for the Teaching of General Science

Willard J. Jacobson

One of our objective in the teaching of general science should be to help young people gain some awareness of the factors that were involved in the growth of a science and an appreciation of some of the methods employed by famous scientists as they tackled problems that confronted them. The study of the relationships between magnetism and electricity and the discovery of how to use magnets to generate electricity provides us with an excellent case history in the development of science. Of atmost importance, many of the critical experiments carried out by Volta, Oersted, Faraday, Henry and others can be replicated in our general science classrooms.

Scientists build on the work of others, and we can quickly demonstrate some of the important things that were known about the relationship between magnetism when Faraday carried out his critical work.

Volta had constructed a useful and continous source of electric current–the voltaic battery. Volta's battery consisted of discs of zinc, copper and paper dipped in water or brine. The paper discs were placed between the zinc and copper discs. This voltaic cell and refinements of it provided a source of electric current which other men used in experimentation.

Oersted showed that, when a compass needle is placed near a wire and an electric current from the Voltaic battery sent through the wire, the compass needle is deflected at right angles to the wire

Arago demonstrated that a bar of unmagnetized iron or steel will be magnetized when placed near a wire carrying an electric current.

Ampere showed that if two current bearing wires that are free to swing are placed near each other they will be either attracted or repelled depending on whether or not the currents are flowing in the same direction in the two wires. The wires are hung so that they are about one centimeter apart at the bottom. One of the ways to make electrical connections that will move easily is to dip the ends of the wires in a pool of mercury.

Starting with this information about the relationships between electricity and magnetism, Faraday carried out a number of experiments that were to make him famous.

Since Oersted had shown that a magnet placed near a wire will turn when a current is sent through a wire, it was suggested that if the magnet were really free to move it would rotate about the conductor. Conversely, a current bearing wire should rotate around a stationary magnet. Faraday set a magnet upright in a bowl of mercury. One end of a copper wire was stuck in a small cork so that it would float in the mercury. The other end was connected through a flexible connection to a Voltaic battery. A lead from the other pole of the Voltaic battery was dipped into the mercury. When a current was sent through the conductor, the wire revolved continuously around the magnet. In this experiment electricity and magnetism were used to produce motion. In other words Faraday had constructed an electric motor.

Ampere had shown that *two current bearing wires* are either attracted or repelled *depending upon the direction* of the current flow and that this force of attraction and repulsion was magnetic. It was also known that an object such as a rubber rod that has been charged electrostatically by rubbing with some material such as wool could induce an electric charge on some other material placed near it. Perhaps *a wire carrying a current could induce a current in another wire nearby.*

"I have had an iron ring made (soft iron), iron road and 7/8ths of an inch thick, and ring six inches in external diameter. Wound many coils of copper round, one half of the coils being separated by twine and calico; there were *three lengths of wire, each about twenty-four feet long,* and they could be connected as one length, or used as separate lengths. By trials with a trough each was insulated from the other. Will call this side of the ring A. On the other side, but separated by an interval, was wound wire in two pieces, together amounting to about sixty feet in length, the direction being as with the former coils. *This side call B.*

"Charged a battery of ten pairs of plates four inches square. Made the coil on B side one coil, and connected its extremities by *a copper wire passing to a distance, and just over a magnetic needle* (three feet from wire ring), then connected the ends of one of the pieces on A side with battery immediately a sensible effect on needle. It oscillated and settled at last in original position. On breaking connection of A side with battery, again a disturbance of the needle."

It should be pointed out that Faraday had tried similar before without obtaining the desired results because he [illegible] d to get a steady generation of electricity. [illegible] iagnetic needle was deflacted only upon the [illegible]

ing and breaking of the circuit in A. However, Faraday succeeded in using current in one wire to induce an trical current in a second wire that had no direct electrical nection with the first wire.

Oersted had shown that a current bearing wire placed r a magnet that was free to swing (compass) would cause magnet to line up at right angles to the wire. Perhaps *magnet were moved near a wire, an electric current could roduced in the wire.*

"A cylindrical bar magnet three-quarters of an inch iameter, and eight inches and a half in length, had one inserted into the end of the helix cylinder (220 feet); then it was quickly thrust in the whole length, and *galvanometer* needle moved; then pulled out, and again *needle moved*, but in opposite direction. This effect was ated every time the magnet was put, and therefore a e of electricity was so produced from *mere approximation magnet*, and not from its formation *in situ*."

It is important to point out that the critical impor- e of relative motion had not been appreciated. *An rical current is generated in the conductor only when the net and the coil of wire are moving relative to each other.* s experiment was the precurser of the electrical generator. night be well to demonstrate the three essentials in the ration of electricity: an electrical conductor, a magnet, motion.

The work of Faraday illustrates a number of impor- points with regard to the way that some scientists work:

1. Scientists build on the work of others. Faraday's rimentation was based on the investigations of such ntists as Volta, Oersted, Arago, and Ampere.

2. Scientists subject their ideas to experimental tests. Faraday was a master experimenter and very able in making and setting up apparatus. His ideas were subjected to experimental tests such as those previously described.

3. Many outstanding scientists are able to come up with imaginative ideas that can guide them in their investigations. One of the key ideas that Faraday had was, in a sense, the reverse of Oersted's experiment. "If an electric current flowing through a wire can make a near by magnet move, then moving a magnet near a wire should do something to the electricity in the wire."

4. Many scientists investigate questions and problems primarily because they are curious or interested in them. For example, there was no indication at the time that anything of commercial value could come out of the investigation of the relationship of electricity and magnetism. Yet, this relationship intrigued Faraday. He began his experiments in December 1824, tried again in November 1825, December 1825 and April 1828. Yet, these experiments gave "no results." But, he came back to the study of electricity and magnetism and in ten days of intensive work in 1831 got the results that have been described.

It was not even clear that his experiments were to be scientifically fruitful. In the midst of his work he wrote to a friend, "I am busy just now again on electro-magnetism, and think I have got hold of a good thing, but can't say. It may be a weed instead of a fish that, after all my labour, I may at last pull up."

[illegible] etimes there are very important practical [illegible] scientific work. We can use the famous story [illegible] to Faraday's laboratory. After touring

aboratory Gladstone is supposed to have said, "Very , Mr. Faraday, but he said what is the use of it?" There wo versions of Faraday's reply. According to one version supposed to have said, "What is the use of a newborn ?" Or, he may have said, "Some day, Sir, you will be to tax it." From the work of Faraday and others, of se, has come the entire electrical industry.

References

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2. Faraday, *Experimental Researches in Electricity*.
3. Kendo, "Michael Faraday" in *Lives in Science*, a Scientific American book.
4. Wightman, *The Growth of Scientfic Ideas*.

Lesson Plan No. 6

Topic : Hard and Soft Water

Objectives

1. After completion of this lesson, the student is expected to discriminate soft, temporary, permanent and hard water.
2. Cite the names of the chemicals which causes hardness in water.
3. Narrate the methods of softening the hard water.
4. experimentally determine whether the water is soft, temporary hard or permanently hard.

Instructional aids : Specimen of various types of water, chemicals as sodium carbonate, test tubes, litmus, sodium bicarbonate, Calcium chloride, Calcium sulphate. Conical flasks.

Content	Teacher presentation	Student's activity
Soft water & Hard water	-Introductory questions on resources of water, soluble insoluble impurities.	
	-Discussion on problem of classification of water according to various properties.	Thinking and citing various ways of classification.

Tempo- ary Hard vater.	(ii) Permanent Hard water.	**Demonstration** **Expt. 1** Effect of soap soln. on soft and hard water.	Observation No. of soap soln. drops.
	1. Permanent hard water contains sulphates of mg and Ca.	**Demonstration** **Expt. 2** Soap soln. test of temp. hard water before and after boiling.	Measuring the thickness of solu in cms.
emporary rd water ntains agnesium lcium carbonate		**Demonstration** **Expt 3** Evaporation of hard water to show the presence of minerals	Investigation Experiment (after evaporation collecting the samples left, then detecting.
		Demonstration **Expt 4** Test of solution of bi-carbonate and sulphates of Ca. & Mg. for hardness.	Detecting hardness from the collected specimen (On comparative basis).
	2. can be obtained by boiling it with washing soda and borax after cooling and decanting.	**Demonstration** **Expt. 5** Removal of permanant hardness by adding and boiling with soda, borax then cooling and decanting the water.	Testing the softness of the water produced.

Assignments :—Test how many other chemicals can c
hardness in water.

—Test the effect of hardness on cer
cooked.

— Reading assignment for permutite process
softening water.

Further activities which can be carried out by stud
themselves—

(i) How many drops of soap solution (*lux so*
are required to produce 1 cm. thickness of su
in bottle having 5 cms diameter.

(ii) What would happen in the above expt. If
take 1% solution and 2% soap solution in t
same bottle.

(iii) Does the formation of suds depend upon tir
of agitation (shaking.)

(iv) What is *ratio* of heights of suds in 25 ml
hard and soft when 1% lux soap solution
added to both of them.

Evaluation

Criteria Test

(1) Hard water is quite unsuitable for :

A. *drinking*
B. cooking
C. washing
D. bathing
E. *agriculture* ( )

(2) Permanent hardness it removed by :

A. *heating the water*
B. adding sodium carbonate
C. *adding* $AgNO_3$ *soln.*

D. bubbling CO_2 through it

E. adding lime water ( )

(3) Permanent hardness is due to the presence of :

A. calcium sulphate

B. sodium sulphate

C. ferrous sulphate

D. zinc sulphate

E. potassium sulphate ( )

(4) The boiler of steam engine is likely to burst because of the accumulation of (if hard water is used).

A. soot particles

B. mud

C. scales

D. bicarbonate

E. common salt ( )

(5) The water which contains magnesium chloride is not used in dying because it will lead to

A. precipitation

B. wastage of dyes

C. weakening of fibre

D. unwanted color

E. fading ( )

(6) (a) Which of the following will give permanent lather (suds) with soap soln.

A. boiled water

B. unboiled water and why ? ( )

(b) What difference did boiling make to the water.

(7) Permanent hardness of water can be removed by :

A. adding washing soda (sodium carbonate) (

B. adding some Borax (sodium pyroborate t the sample).

C. by both ways

D. by none of the above (

(8) (I) What chemicals are likely to be contained in :

(i) *Temp. hard water?*

(ii) Permanent hard water ?

(9) Where from do you expect these chemicals to ente into the water on nature.

(10) What is the effect of evaporation of soft water in comparison with the avaporation of hard water.

Lesson No. 7

M. K Gupta

Subject : General Science *Topic* : Burning (to be converted in two periods of 40 minutes)

About the lesson

The teacher is not sure about the sequence in which the pupils will learn the content material. The sequence depends upon the questions the student ask, or the material of learning teacher organises in class. However the teacher is clear about the objectives of teaching this unit. He is prepared for teaching the unit in any sequential order that may come out of the discussion with pupils.

Objectives

(a) Content : Pupils recognises that :

(i) buring of candle starts with the burning of thread first.

(ii) wax melts.

(iii) Molten wax changes into vapour form.

(iv) wax vapours burn and candle gives light.

(b) Process objectives :

(i) observe the phenomena

(ii) formulate hypothesis

(iii) Design experiments to test the hypothesis

(iv) draw inferences from results.

Initiating activity :

(i) The teacher places a lighted candle on the table and asks this question

Q. Which part of the candle is burning ?

Q. Which pars burnt first ?

(ii) Distribute the candles in a group of six and ask them to lit it by themselves.

(iii) Repeat the same question (No. 1)
(Every answer would be in the form of hypothesis)

Teacher makes a list of the hypotheses that the pupils give and ask them to suggest the method to test each of the hypothesis (In case the pupils fail to design the experiment–the teacher himself suggests the method.)

Hypothesis	Experiments (Testing of hypothesis)	Key points
The thread burns	A thread is taken by a pupil and is burnt. The pupils are asked to describe the difference between the burning of candle and burning of thread.	Thread alone burns immediately but in candle it continues to burn.
The wax burns	The teacher gives a piece of wax to a student and asks him to burn it.	It melts but does not burn.
	A student will be asked to burn the candle at the bottom where the thread is not protruding.	
Molten Wax and thread together burn	Teacher tries to light the liquid wax taken in a watch glass.	Wax does not burn.
When mixed,	But the cotton thread into molten wax in watch glass and light.	Wax burns now.

Conclusion

Thread and molten wax burn together and thread when alone, but wax alone does not.

Q. At which part of thread, burning is taking place ?
Student answers : Upper most part.
Why ? Why not at otherpart ?
Here teacher helps the student by performing the experiment himself. He put the small glass tube into mid of flame when candle is burning & ask the question.
Students observe keenly.

(i) What is coming out of tube vapour of wax ?
Teacher burns vapours with match and it burns at top

(ii) Whether liquid wax burns—No.
What happen to the liquid wax before burning—Change into vapours.
Where these vapours are present—At the top of thread.
Why ? Temperature is high.

Now describe the burning of candle from the very beginning. Statement by the teacher—in the last.

Importance of keen observation, framing of hypothesis, designing expt. to test aud drawing inferences.

Assignment

Devise expt. about burning of coconut oil in house. You may take help of cotton wick if required.

References—(1) Chemistry an experimental Science-Chem Study 1st Chapter.
(2) Faradays Lecture about candle.

Pedagogical Institute in U.S.S.R.

A. N. Bose
Raj Madhav Rao
Raghavendra Rao

Great attention is paid to the problem of training teaching personal. Therefore a net work of Pedagogical Institute all over the country is responsible for a steady growth of educational standard in the country. One special feature in USSR is that same amount of importance is given for the training of elementary school teachers as given for training secondary school teachers and all pedagogical institutes have training facilities for both types of teachers. The system of teacher training has undergone changes and has been kept as a dynamic programme. More thought is given to problems such as methods and organisation of education, improvement of service and standards of teachers, devising new teaching aids and publication of useful literature for teachers at all levels. There are nearly two hundred pedagogical Institutes in USSR. The Lenin Pedagogical Institute at Mascow is one of the biggest teacher training centres in USSR. All these Pedagogical Institutes train teachers both in humanities and in science. Some Institutes like Lenin Pedagogical Institute in Moscow and Hertsen Institute at Leningrad are statutory bodies with the right to confer their own diplomas. In USSR secondary school teachers are trained both at the Pedagogical Institutes and in the Universities, of course the Universities train only a few teachers compared to millions of teachers trained in Pedagogical Institutes. Each ...gogical Institute is headed by a Rector.

etails regarding Lenin's Pedagogical Institute at Moscow

This Institute has many faculties and these faculties e working in different buildings which are in different arts of the city. The Institute has facilities for training achers for elementary and secondary school in all subject reas, including defectology. The Lenin Institute is a atutory body with the right to award diplomas. Students ho have passed ten years of schooling are eligible to seek dmission to this Institute for a four year or five years rogramme. The pupils seeking admission to this Institute iust take an entrance examination. Competency in the inguage is considered as a vital factor in selecting a tudent for teacher training. If a student has secured a ery high percentage of marks in his final high school xamination he may be exempted in the entrance examination in that particular subject in which he has secured istinction. The Institute has facilities for teaching many oreign languages like English, French, German and Spanish. Training is given both in humanities and in science in this nstitute There is also provision to give higher education o elementary school teachers in the Institute. The Institute does not offer any special courses in physical education.

The students who major with one subject generally have a course of four years duration. In some faculties opportunities are afforded to specialise in two subjects like physics and mathematics or chemistry and biology, in order to meet the needs of teachers in rural areas. In such schools there may not be adequate number of working hours for a single subject teacher. In such cases the course will be of five years duration. When these teachers with two subjects work in a school the total working load will be

the same as that of single subject teachers. In the course of two majors the depth of content matter in each major area is less than what it is in one major subject course.

The theoretical programme in a Pedagogical Institute consists of the following :

(1) Social and economic subjects—11-15% of the total programme.

(2) Pedagogical subjects, like pedagogies, history of pedagogy. Psychology, school hygiene and various methods constitute 11% to 15% of the total programme.

(3) Special subjects in the fields of major and minor constitute 70% of the total programme.

Soviet Pedagogy is taught in the second year and history of education in the third year. Soviet Pedagogy includes mental education, moral education, labour and polytechnical education, aesthetic education and physical education. Much attention is paid to the study of the major subject and practice teaching in the third and fourth years Fourth year is mostly devoted to consolidation of subject matter and practice teaching. Many of the faculties in these Pedagogical Institutes offer courses of application of scientific knowledge in the national economy.

Some of the important features of the academic programme of the Institutes are : (1) The curriculum in methods of teaching is very closely corelated to the secondary school curriculum (2) The major emphasis in the programme is on the speciality. (3) The methods of teaching science for example is on a high degree of practical bias. It deals with the high school curriculum ' trains the students in such a way as in a real class

om situation. There are specially designed methods oratories where the student teacher can do school monstration experiment and also other useful and eresting experiments which are quite essential in the ching of other science topics. (4) In the faculty of emistry for example there are two sections one for content ea and another for methods of teaching chemistry. The ethodology of chemistry by itself is pedagogy.

Each pedagogical Institute has a number of perimental schools attached, where new programmes, new periments and new teaching techniques can be tried by e staff of the Pedagogical Institute.

ach r Education Programmes in Pedagogical Institutes

Since the demand for trained teachers is very great, l the resources of the pedagogical Institutes are fully ilised in various ways to prepare as many trained achers as possible. With this end in view many of the edagogical Institutes in USSR have three kinds of teacher aining programmes.

(a) Day course for regular students, (b) Night asses for those who are already teaching in school in wer classes but who have no higher education, (c) orrespondence course for those who are working but not in position to attend the night classes for reasons of istance etc.

) Day time courses for regular students

The course is of four years duration if the student eachers are majoring in one subject and it is of five years uration if two subjects are chosen as majors.

'ractice Teaching

In the teacher training programme greatest emphasis

is paid on acquiring mastery in the major subject and one practice teaching. The duration of practice teaching varies from one Institute to another in USSR. Generally the period can be taken as eight to twenty weeks. The student teachers are first exposed to the pedagogical experiences during the summer vacation after the first year in pioneer camps. In these camps the student teachers have an opportunity to observe how the co-curricular activities are organ sed, uderstand the psychology of children, mingle with them and guide them in their activities so that they acquire all the traits of a future teacher. In the second year the students have what is known as passive practice They go to good school, assist the senior teachers in their laboratory work and demonstration work and observe the teaching techniques used by the senior teachers The passive practice is continued in the third year also. The student teachers are taken to as many good schools as possible and given ample opportunities to benefit from the rich experiences of seasoned teachers. In USSR due recognition is given to good teachers and the student teachers are always given guidance by these teachers. The active practice teaching commences in the fourth year. This programme of active practice teaching is completely planned, supervised and evaluated by the methods faculty of content subject such as physics, chemistry etc. They are fully incharge of practice teaching. The general education department members occasionally accompany the methods faculty members and render assistance when required. In selecting the schools great care is taken to see that all the conditions are quite congenial for a student teacher to do active practice teaching. His individual abilities and demerits are taken note of in planning his programme. The student teachers work under the guidance of senior teachers of good schools. The director of the school also gives valuable guidance to the student

teachers. For this extra work of guiding the pupil teachers the director of the school as well as his staff are paid extra remuneration. The senior teacher helps the student teacher in the prepartion of various kind of teaching aid including audio-visual and also help the slow learners in the school during the spare time. The pupil teachers are also expected to do social work. Pedagogical practice is given great importance both by the Institute and the student teachers The supervision and evaluation of the lessons given by the student teachers is done mostly by the director and faculty members of the school where the student teacher is doing practice teaching. Members from the methodology faculty of the pedagogical institutes also supervise and evaluate the lessons as many times as possible.

(b) Evening or Night Classes

The programme of four years is extended to five years in the night class course and the subject matter is condensed. These classes are mainly meant to give facilities to those teachers who are working as teachers already without higher education. In the night classes also a variety of subjects are offered in the training programme The physical education and defectology are not included in these programmes Foreign languages like English, French and German are included in this programme. Even experimental science subjects such as Chemistry are in the night class programme.

The students of the correspondance courses are allowed to attend the night classes or the day time classes according to their individual convenience. The number of hours for this programme is sixteen hours per week. In general the faculty members of the night class constitute a separate entity from the day time faculty. A very large number of teachers attend these courses and acquire higher education.

Details Regarding the Physical Science Programmes in Teacher Education

More details regarding the curriculum, duration and techniques adopted are furnished with particular reference to the individual programmes in physical science for a comparative study between the programme in the Regional Colleges and in USSR.

Mathematics

Mathematics Faculty is one of the biggest in the pedagogical Institutes in USSR, e. g the Lenin Institute at Moscow, has 700 students in the day department and 300 in the evening section specialising in mathematics. There are three types of courses in the Mathematics Faculty.

(a) Preparation of Secondary School teachers in Mathematics-four year course.

(b) Preparation of mathematics teacher and programme instructors for computors–five years course.

(c) Preparation of mathematics teacher with special training in foreign languages such as German, English and French–five years course.

In the evening department only the first course is given which is of five year's duration.

The pattern of curriculum is as follows

The general disciplines are same as for all the courses which has already been discussed.

Content in Mathematics

(1) Analytical geometry, (2) Mathematical analysis (3) Higher algebra. These are taught for first two and a half years which comes to about 450 hours. (4) Theory of

functions and complexes, (5) Higher Geometry differential, practical and foundation geometry, (6) Theory of numbers-theoretical arithmetic and elementary mathematics. All these courses are covered in four years. Besides these, there are some optional courses for specialisation.

Methods of teaching Mathematics

This is taught during the 3rd and 4th year in order to acquaint the students with different methods of teaching. This is taken up by the chair of mathematics methodology.

Besides all these, there are other intermediate subj.cts such as mathematical physics, astronomy, theoretical mechanics and mathematic practical. Elementary course of physical culture and foreign language is common for all. A total number of 1400 hours are devoted to these topics.

Practice teaching is on the same lines as indicated earlier in the general pattern of the teacher training programme. The day time students go for practice teaching in the third and fourth year where as the evening course students go for practice teaching in the fourth and fifth year since their course is of five years duration.

Apart from practice teaching the student teachers in mathematics undergo a special course of 150 hours working with calculating machines and electronic computors. This is one of the unique features worthy of emulation by the mathematics faculty of all pedagogical institutes in India.

Mathematics Laboratory work

Mathematics is taught not merely as a theoretical science but as an experimental one also. There are different types of laboratory work in the field of mathematics. In

the electronic computor laboratory, the student teachers are given training of preparing programmed materials, feeding the programme into the computor machine, analysing the results and drawing inferences. They are also acquainted with the mechanism of the computor machine though there are especially trained technicians for maintaining the computor. The students also work with different types of calculating machines and acquire mastery Another special feature in regard to practical work is that the students do a number of experiments in mechanics, electricity, magnetism, spectroscopy etc. in the physics laboratories and each mathematics faculty has several well equipped physics laboratories also. Another special point to note is that all these experiments in physics are related to applied mathematics

In mathematics faculty there are number of chairs in branches like mathematical analysis, theory of number, mathematical physics, algebra, geometry, and methods of teaching mathematics.

The Mathematics laboratories have all the facilities for post graduate research work and many aspirants work for the degree

Chemistry

Generally the chemitry programme is of two types: (a) Course of four years duration & (b) course of five years duration. Four year course is for majoring only in chemistry and the other course has two major subjects like biology and chemistry or chemistry and foreign language. The scope of the syllabus is more or less the same in these courses but the depth of the subject matter in chemistry differs.

The faculty of chemistry in general offers facilities for specialisation in physical chemistry, organic chemistry, nic chemistry, analytical chemistry, industrial chemistry.

and methods of teaching chemistry. Accordingly there are number of chairs in the chemistry faculty of the pedagogical institute. The general education programme is the same irrespective of the major subject, which has already been discussed. The chemistry programme in particular is as follows:

Ist Year

Higher Mathematics	— 148 Hrs.	
Physics	— 162 ,,	(50% practical and 50% lecuters).
Inorganic chemistry	— 340 ,,	(100 lec. + 240 practical)
Mineralogy crystal	— 54 ,,	(18 lec. + 36 practical)

IInd Year

Higher Mathematics	— 36 Hrs.	
Physics	— 133 ,,	(50% lec. + and 50% practical)
Analytical chemistry	— 340 ,,	(36 lec. + 304 practical)
Organic chemistry	— 180 ,,	(100 lec. + 80 practical)
Lab. safety measurements	— 20 ,,	(10 lec. + 10 practical

IIIrd Year

Physical Chemistry	— 220 Hrs.	(100 lec. + 120 practical)
Organic Synthesis	— ,,	(practicals Only)
Chemical technology	— 66 ,,	(44 lec. + 22 practicals)
Polymers	— 45 lectures	
Agricultural Biochemistry	— 20 lectures	

Methods of teaching Chemistry	—	140 Hrs. (150 lec.+90 practical)

IVth Year

Colloid Chemistry	—	80 Hrs. (40 lec.+40 practical)
Inorganic synthesis	—	80 „ practicals
Chemical technology	—	114 „ (26 lec.+88 practicals)
Special Course	—	50 „ Practical
Special Practical	—	150 „ do
Agricultural biochemistry	—	20 lectures.

Special practicals are research oriented. The student can make use of this research for this diploma or later on for the candidate's degree.

The methods practical is commenced in the second term of the third year and finished in the fourth year. A total of 120 hours (50 Hrs. lectures+70 hrs. of Laboratory work) are devoted for this.

If the course is five years duration, in the fifth year the work in the specialised field is continued.

Another special feature is that the student teachers are given practical training in chemical plants. For example after first year the students work for fifteen days, after the second year for three weeks and after the fourth year for four weeks in chemical factories.

Laboratories

The following are the laboratories attached to the chemistry faculties of the pedagogical Institutes. (a) Physical Chemistry (b) Organic Chemistry (c) Analytical Chemistry

(d) Colloid Chemistry (e) Inorganic Chemistry and (f methods of teaching chemistry. All these laboratories a equipped with instruments like electron microscope, polar graphs, different types of spectroscopes etc.

Five Year course for the Preparation of Biology and Chemistry Teachers

A special reference is being made for this course which teachers of biology and chemistry are prepare This is of five years duration. The courses in inorgan general and analytical chemistry are the same as in the fo year programme. 60% of the course is for biology ar 40% is for chemistry. In rural schools the work load a single subject will not be quite adequate and these tv subjects teachers are prepared mainly for such rural schools

Physics

Generally the Physics teachers' training programme of four years duration. But there are some institutes USSR where they have five years course and they tra teachers of Physics and Mathematics or Physicst eachers teach it in English or German medium. The syllabus general is the same but in the case of five years course Physics teachers in English or German the depth of the conte matter in Physics is higher than in the four year course.

The demand for well trained physics teachers is gre in USSR as in other countries. Only meritorious studer with distinction in Secondary Schools are generally allow to appear in the entrance examination. The Lenin ins tute of Pedagogy (physics), Moscow, holds a prepato course for about six months and trains candidates for t preparatory examinations. The pupils pay a fee of 20 rubl and they are trained in Physics, Mathematics, Chemistr

Russian Literature and in Foreign languages. The entrance Examinations are held in these subjects only and mostly they are oral type. The selection committee consists of subject specialists and while selecting the candidates they look in to their performance in the examination, interview result as well as their medical fitness.

In the Physics teacher's training programme they have given very great importance to the study of higher mathematics which covers about 650 hrs. They teach analytical geometry, mathematical analysis and mathematical physics which serve as the foundation to their study of higher physics later on. The pattern of pedagogy and general education is nearly the same as mentioned earlier but there is some difference in the allotment of time etc. The programme of Lenin Institute is given below :

No.	Subject.	Periods Total	Periods Lectures	Lab/ Seminar.
I Year				
1.	History of Communist party.	120	50	70
2.	Audio Visual Aids	40	10	30
3.	Foreign Language	183	—	183
4.	Physical Education	70	—	70
5.	Analytical Geometry	110	60	50
6.	Mathematical Analysis	300	160	140
7.	General Physics	160	60	60+40
8.	Workshop Practice	70	—	70
9.	Lab. Safety measurements	24	12	12
II Year				
1.	Philosophy	120	50	70

2. Psychology	72	54	18
3. Pedagogy	40	20	15+4
4. Foreign Language	57	—	57
5. Physical Education	70	—	70
6. Mathematical Analysis	150	80	70
7. Mathematical Physics	90	54	26
8. General Physics	350	120	120 + 110
9. Theoretical Mechanics	108	54	54
10. Workshop Practice	60	—	60
III Year			
1. Political Economy	80	30	57
2. Pedagogy	40	20	15 + 5
3. School Hygiene	80	80	—
4. Methods of teaching Physics.	170	40	90 + 40
5. General Physics	190	60	60 + 70
6. Theoretical Physics	160	110	50
7. Astronomy	110	70	40
8. Electrotechnics	110	40	60
9. Radio Technics	130	40	90
10. Microscope Electrodynamics & relativity theory.	96	60	36
11. Quantum Mechanics	90	60	30
12. Practical works in Technical models.	36	4	32
IV Year			
1. Foundation of Scientific Communisim	70	30	40
2. History of Pedagogy	60	40	20
3. Theoretical Physics	170	120	50
4. Principal of nuclear Physics.	24	24	—
5. Practical work in Technical models.	14	—	14

6.	Special Course	104	36	68
7.	Thermodynamics and Statistical Physics.	90	60	30
8.	Electron Theory.	50	40	10

As mentioned in the Chemistry the Physics teacher are also given some specialisation like solid State Physic X-Ray structural analysis, Physics of Polymers, Molecula Spectroscopy, Magnetic Hydrodynamics, Physical optics, quantum Radio Physics, High Frequency Physics, Physics o Semiconductors Automatics and Tele-communication and in *Methods of teaching physics. In addition to this they have* some special practical work like (i) Mechanical properties of solid state (ii) Physics of Polymers (iii) X-Ray structural analysis (iv) Molecular Spectroscope (v) *Radio Physics* and (vi) Practical work in Methods of teaching and techniques of School experiments. Student is allowed to choose any one special course and one special practical work.

The practice teaching is mostly guided and supervised by the chair of Methods of teaching Physics. The students *have different types of training. First of all they work* in the Pioneer camps for about four weeks and guide the school children and during the VI term they have 7 weeks practice teaching *in Schools where they handle lower* classes from VI to VIII and lastly they have 15 weeks practice teaching during the VII term where they teach higher standards. The practice teaching is supervised *by the tea*ching staff of the Methods chair and school teachers. The teaching staff of the Pedagogy occasionally come and give their help.

Subjects marked are taught in two years or [illegible] and the [illegible] of hours is approximately shown above. In [illegible] they have both practical and seminars within the [illegible] [illegible].

Appendix B

Evaluation System at School and College Levels in USSR

A. N. Bose
Raj Madan Rao
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A good evaluation system is just like a beacon light to any educational programme. If the evaluation is organised properly one can look back as well as look to the future of the programme very effectively and good tools of evaluation are guide lamps. In all countries the ways and means of evaluation of teaching and learning have posed many baffling problems and USSR is no exception to this. This problem has received the best attention of all educationists and attempts are being made every now and then, to think of new tools, new criteria and new devices for evaluation of learning as well as teaching.

The system adopted in USSR is some what different from the Indian, British and American patterns.

Evaluation in school programme

There are State examinations towards the end of the eighth grade and tenth or eleventh grade (depending upon whether it is a ten year school programme or eleven year school programme). Besides this there are a number of class room tests both, written and oral through out the year in all the courses. Great stress is laid upon oral examination for evaluation of knowledge acquired by the students. In

subjects like Russian language, foreign languages and r matics the students are tested by written tests often in ad to being examined orally. In subjects like Chemistry, p etc, more weightage is given to oral examinations.

The assessment of the knowledge of the pupils is continuously through out the year during the peric instruction by allocating a definite portion of time *instruction hour* for evaluation of pupils. This syste the advantage of making the student being alert al Whether it is oral examination or written examit marking is always done on a five point scale. If the an are excellent five marks are awarded. If they good four marks are awarded. If they are satisfa and if the students can be improved upon three r are awarded. If the students show complete lack of k ledge he is judged bad and given two marks and one is r given. Students who score less than three are deem have failed. The percentage of students failing is negli Since all attempts are made to watch the progress c student well rendering all assistance and see that he impr

The following are the methods adopted in day to work for evaluating the knowledge acquired by pu During the time allocated, student is asked to come to table, given some task like explaining the answer to a que related to the previous lesson,, or demonstrate a partic experiment. During this time the pupils are allowed to supplementary questions and discuss the answers. student is graded and given marks for this task fulfilln according to his ability. By this method in the time all for evaluation in each period, four to five students ca evaluated. The teacher can pick up any student with previous intimation and this makes all the students alv alert. This is one method of checking up the indivic

knowledge. It is felt by the eductionist that the following are the draw-backs in this method : (1) when a student is explaining the answer it is difficult to make all the pupils listen to his answer and keep them actively interested in the lesson, (2) if the student chosen for evaluation happens to be a weak and dull student, his answers will be un interesting to every one and also will be wasting of other's time.

Many progressive teachers feel that it is better to minimise the time for checking up the individual knowledge and devote more time to check up the total learning. A few questions are put to the entire class by the teacher. There will be response by way of raising hands and those who do not know the answer are easily spotted out. The teacher can give the chance to answer to any pupil according to his discretion. The teacher can have certain students in mind during the process of questioning and even grade him. In this method it is difficult to test the knowledge but it is easy to keep all the students active This system is becoming more popular.

The third method adopted is called the combined method of questioning. A few students (three to four) are asked to work out some problems on the different portions of the black board assigned to him. A few students are supplied with question cards and asked to prepare the answers. A few others are called by the teacher and orally examined. Draw-backs of this method are (1) there is scope for malpractice. When the teacher is busy orally examining some students, the other students can help each other in working out the problems and it will be difficult to know whether the student is independently capable of tackling the problem. (2) It creates indiscipline because a student who finishes his assignment earlier will be idle and

an idle mind is worse than a devils workshop. (3) One student will not know what the other student is doing and the sense of a class as a unit is consciously absent. But the method enable the evaluation of number of students at a time.

In all the above methods of evaluation the students are informed of the grading of the marks immediately so that they can know their strength and weakness.

Day sheets are maintained in a register where the details in regard to the performance of students with particular reference to topics and the question are recorded. The day register has the following column.

Date	Name of Student	Marks	Title of the Lesson & nature of Question.	Home task.	Remarks

This table also gives information as to which student was absent on a particular day and what lesson he missed. The director of the school looks into this register now and then and gives his own comments.

Towards the end of each quarter, the marks are consolidated for students. Above eighth grade there are only two terms, for others three. In the final evaluation the teachers judgement is of supreme importance. The final marks may be the average of the various marks or it may be the marks obtained in the last stage of the term.

The modern trend is to have in addition to the above mentioned methods, more objective type tests. Test for mental ability [illegible] accepted in Soviet pedagogy and there is no pl[illegible] achievement test papers [illegible] It is also

felt that more weightage should be given to written
in order to develop the abilities of expression and marsha
of facts. Many technical devices that are used in
ramme instructions are being used for testing, teaching
self learning. Test items are being standardised and
attempt is being made to test not merely knowledge bu
understanding and skills. For multiple choice tests,
machines like the punch board, electrically operated
button machines and a number of new devices are
devised and improved upon.

State Examinations at School level

There are two state examinations one towards
of the eighth grade and another towards the end of
eleventh grade depending upon the programme. A
commission is incharge of conducting these state e
tions. The Commission consists of seven members.
who teach the particular subject in the school, s
in that particular field, regional director of educa
representatives from educational organisation consi
commission, of which the director of the schoo
chairman. This commission is the examining bo
examination cards are very carefully prepared by th
of education in such a way as to cover the entire syl
also as to enable to evaluate knowledge, understa
skills. These examination cards are published i
of booklets well in advance (four to six months e
are sold in the market. Each book consists
examination tickets for the same course. In
there will be three to four questions Details pe
these tickets are worked out by the concer
teachers. At the time of examination, the stud
question by drawing of lots. He is given time b

to solve these question orally, or in writing or on the bl board depending upon the nature of the questions commission has got powers to put alternate questions give full scope to the student. The main principle be this system is to try to find out that the student knows not try to find out what he does not know. There wi both oral and written examinations for subjects like Ru and foreign languages and mathematics. These que papers include topics of the previous classes also. question paper in composition resembles the pattern in In Such papers are given to the students only at the tim examination and strict secrecy is maintained regarding question papers. Due weightage is given to the class r and in the final diploma the total of the marks acq during the course and the state examination is entered. importance is attached to the opinion of the subject te who will have a intimate knowledge of the students. is possible because of the compactness of the class strength of which does not exceed thirty five.

Examination in Pedagogical Institutions

Day-to-day evaluation as in schools is not prevele the pedagogical institutes. The academic year consis two terms and there will be terminal examinations certain ... jects the students are examined twice ... others only once in a year. The conducted by a special board not ... consists of professors of the In... The grading is done on a five ... school level. Examination c... of the Institute.